The subjective side of cognition –
On the development of non-cognitive variables influencing cognitive development across the adult lifespan

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ABSTRACT

The four studies summarized in the present thesis were conducted within the overarching framework of asking how and by which means individuals manage and influence their own cognitive development. Two aspects were addressed specifically: First, the development of individual differences in the extent to which individuals deliberately engage in cognitive activities and, hence, influence their own cognitive performance. Second, the development of individual differences in the metacognitive skill of subjectively estimating one's own cognitive performance and its potential influence on cognitive development. Following the elaboration of the theoretical background in chapter 1, in chapter 2, the following questions were addressed in detail: Are there age differences between young and old adults in Typical Intellectual Engagement? Are presumptive differences related to known age differences in related constructs? (*Study 1*). How does Typical Intellectual Engagement develop across five years in old age? Are there interindividual differences in the development of Typical Intellectual Engagement? (*Study 2*). Chapter 3 examines the accuracy of metacognitive subjective memory complaints in populations of individuals for whom the management of their lowered cognitive resources may be decisive for their everyday functioning (*Study 3)*. In these populations of memory clinic outpatients the accuracy of complaints may be decisive to trigger extra-effort to ensure normal everyday functioning, because formerly highly automatized processes might then need deliberate effort and resource allocation. Due to that, the processes should be more salient in groups of outpatients and might, thus, be better assessable. In *Study 4* the question whether the relation between subjective and objective cognitive performance is assessed more adequately by investigating commonalities in change was addressed. The empirical evidence of *Studies 1* and *2* demonstrate substantial interindividual differences in Typical Intellectual Engagement that are not captured by ability measures or potentially related personality trait measures. *Studies 3* and *4* reveal that

cognitive complaints are more strongly related to specific cognitive domains than to global cognitive measures. Also, the relation between the constructs is higher when taking a change-oriented approach. However, overall, it remains moderate. In chapter 4, all findings are integrated in an overall discussion. Shortcomings of the present studies and theoretical implications are addressed. Suggestions for future research directions focusing on the functional relevance of cognitive abilities, metacognitve skills and intellectual engagement are made.

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1. INTRODUCTION

Demographic changes show that, in Switzerland, life expectancy at birth for men and women has increased from 68.7 years and 74.1 years in 1960 to 80.1 years and 84.5 years in 2010, respectively (Bundesamt für Statistik, 2010, 2011). At the same time, research on ageing has added empirical evidence to the growing awareness that development in old age does not just equal decline but also comprises the possibility of increase and of maintenance of high levels of functioning (for an overview see Lehr, Thomae & Diehl, 1987; Lindenberger, Smith, Mayer & Baltes, 2010; Steverink, Westerhof, Bode & Dittmann-Kohli, 2001). Cognitive ageing has received a great deal of attention because it is essential for subjective wellbeing (Lawton et al., 1999) and represents an important prerequisite for preserving a high functional level in all other areas of daily living in old age (Baltes & Lang, 1997). Therefore, one central goal of ageing research is to understand the mechanisms that underlie cognitive changes across the adult lifespan.

Overall, broad consensus exists on the fact that cognition changes across the lifespan (e.g., Baltes, Cornelius, Spiro, Nesselroade & Willis, 1980; Verhaeghen & Salthouse, 1997). Generally, decline in performance as a function of age has been the most persistent finding across various cognitive domains (e.g., Craik & Bialystok, 2006; Deary et al., 2009; Gallucci et al., 2009; Salthouse, 2009; Verhaeghen, Salthouse, 1997). This is especially true for the "fluid" domains such as speed and reasoning, whereas for knowledge stability or even increase has been found with decrease starting only very late in life (e.g., Schaie 1996; Singer, Verhaeghen, Ghisletta, Lindenberger & Baltes, 2003; Zimprich & Mascherek, 2010). Many of the existing and widely recognized theories that try to account for cognitive changes mainly draw on cognitive variables to explain cognitive changes. That is, changes in basic cognitive functions, such as speed of information processing, are postulated to explain

changes in specific cognitive functions (e.g., Cattell, 1987; Craik & Byrd, 1982; Hasher, Stoltzfus, Zacks & Rypma, 1991; Hasher & Zacks, 1988; Salthouse, 1996). However, these theories can neither account for all variance in cognitive development nor the large interindividual differences between individuals who are endowed with the same level of abilities. Hence, other theories take environmental demands and unique person characteristics other than cognition into account to explain differences in cognitive ageing. The main focus of these theories lies on the personal agency of individuals. The theories describe the engagement in everyday activities and the dispositional tendency to engage in specific activities to influence cognitive development. Also, ability management through metacognitive functions is addressed. Ability management refers to the monitoring and self-evaluation of cognitive functioning. Based on that, individuals can deliberately adjust effort in order to maintain desired functioning (e.g., Ackerman, 1996; Anstey & Christensen, 2000; Cattell, 1987; Cavanaugh, Feldman & Hertzog, 1998; Hertzog & Hultsch, 2000; Rowe & Kahn, 1997; Scarmeas & Stern, 2003).

Before embarking on the four studies of this thesis that will investigate aspects of individual, non-cognitive variables, in what follows I will discuss the role of non-cognitive aspects in cognitive development and will present theories that have included non-cognitive factors (1.1). Next, I will outline the concept of Typical Intellectual Engagement as one important person characteristic influencing cognitive development (1.2) and, lastly, I will focus on and further elaborate on metacognition, especially subjective self-reports and their relation to cognitive functioning (1.3.). In a brief excursus I will then discuss some methodological issues of examining change in developmental research and the concept of measurement invariance (1.4.). From this, the research questions of the current work will be derived (1.5.), and the studies then will be presented in two chapters (2 and 3). Finally, a comprehensive discussion of the four studies will be provided (4). The discussion intends to

integrate the empirical evidence of all studies, deriving their theoretical implications, and providing suggestions for future research.

1.1. Development in context

Hertzog's (2009; Hultsch, Hertzog, Small & Dixon, 1999; Salthouse 1991) adage "use it or lose it" trenchantly illustrates the central point of theories that emphasise the importance of environmental demands and individual factors other than intellectual abilities for cognitive development. In the last years, theories have emerged that underscore the influence of motivational and personality factors on cognitive ageing. On a very general level Baltes' and Baltes' (1990) Selection, Optimization, and Compensation (SOC) model aims at explaining individual differences in ageing in terms of individually chosen goals in which to invest increasingly limited resources. The SOC model (Baltes & Baltes, 1990; Baltes & Carstensen, 1996; Freund & Baltes, 1998) can serve as a general framework to understand an individual's competence to deal with losses and challenges effectively across the lifespan. The selection-process concerns the focus on fewer goals in the presence of limited resources (e.g., Freund & Baltes, 1998). Optimization is concerned with the investment of resources in order to achieve higher levels of functioning in the domain of the chosen goal (Baltes & Baltes, 1990; Baltes, Staudinger & Lindenberger, 1999) and, finally, compensation describes dealing with losses and restructuring abilities in order to maintain a certain level of functioning in the non-selected domains (Freund & Baltes, 1998). All three aspects refer to beneficial processes between psychological characteristics and the external context of an individual (Gestsdottir, Lewin-Bizan, von Eye, Lerner & Lerner, 2009; Lerner, 1982). By contrast, the concept of successful aging (Rowe & Kahn, 1997) advocates the idea of the "maximization of functional status" (p. 436). Rowe and Kahn stress the importance of lifestyle factors and individual agency. Individuals are described as active parts in designing their own aging process (Weir,

Meisner, Baker, 2010). Together with theories that propose lifelong plasticity and the multidimensionality as well as the multidirectionality of development, the individuals' spheres of influence and their individual characteristics come into focus (Baltes, 1987; Baltes & Schaie, 1976; Willis, Schaie & Martin 2009). In lifespan developmental research the concepts of multidirectionality and multidimensionality advocate the integration of gains and losses throughout the lifespan. Different subcomponents of, for instance, intellectual abilities follow different developmental trajectories. Development is not simply marked by one-dimensional growth defined as increase in size or efficacy (see Baltes, 1987). Rather, for different abilities gains and losses may emerge at any stage of the lifespan in different manners. The theories referenced define the scope where individual influences can manifest themselves in the course of development. While the theories referenced demonstrate the extent of individual influence in a general framework of lifespan development, other theories have come up that explicitly address personal variables in the context of cognitive development (cf., Ackerman, 2000; Cattell, 1987; Hess, 2005).

In a comprehensive review on contextual factors influencing memory, Hess (2005) named proximal factors (such as everyday activities, unique occupational experiences, personality, and motivation) and distal factors (such as occupational roles, participation in culture) that act on cognitive development throughout the adult lifespan. The distal factors are addressed more formally in the environmental complexity hypothesis (Schooler, 1984; Schooler & Mulatu, 2001; Schooler, Mulatu & Oates, 1999). In his theory, Schooler postulated that complex environments are cognitively more demanding. To the extent that the cognitive effort to get along in this environment is rewarded with success, the positive reinforcement leads to higher motivation to engage in cognitive demanding activities or live in cognitive demanding environments. What Hess describes as proximal factors is functionally integrated in the concept of cognitive reserve (Scarmeas & Stern, 2003).

Scarmeas and Stern postulated that the type of daily activities significantly influences the resilience an individual develops to attenuate cognitive decline. Referring to the concept of plasticity of cognitive abilities they postulated that performing highly demanding activities, living in a constantly changing environment, or deliberately training cognitive processes results in a permanent use and preservation of cognitive abilities (Scarmeas & Stern, 2003). Research has shown that high levels of (cognitive) activities can function as a buffer against cognitive decline (Colcombe & Kramer, 2003; Ghisletta, Bickel & Lövdén, 2006; Hertzog, 2009; Hultsch et al., 1999; Scarmeas et al, 2011; Schooler & Mulatu, 2001; Stine-Morrow, Parisi, Morrow, Greene & Park, 2007). These effects are present even in old age (cf., Schumacher & Martin, 2009) and may pertain over a long period of time. Kåreholt, Lennartsson, Gatz and Parker (2011) showed that cognitive engagement in midlife was positively related to cognitive performance up to 20 years later. Although no one wants to claim that decline in cognitive functioning when getting closer to death in old age is anything but inevitable, the research cited above hints to the fact that individuals can actively influence their own cognitive development. In the following, I will discuss two theories that provide a framework for cognitive development that explicitly consider the influence of individual differences variables and activities.

1.2. Investment theories

In what follows I will outline two theories of intellectual development, namely Cattell's (1987) investment theory and Ackerman's intelligence-as-process, personality, interests, and intelligence-as-knowledge (PPIK; 1996), that both try to integrate biologically determined aspects of cognitive development with flexible, highly individual aspects of cognitive development. Both theories include non-ability aspects in cognitive development such as personality, motivation, and interest. Also, they advocate the idea of (deliberate) selection in which fields to invest intellectual capacities.

Based on the formulation of theories on the structure of intellectual abilities (Cattell, 1967; Horn, 1968; Spearman, 1904; Thurstone, 1938), Cattell postulated his investment theory (1987) as an approach to understand the development of cognitive abilities. He proposed that although intelligence is constrained by biological components, in the course of development, motivational and personality aspects become more and more influential. Cattell's investment theory was derived from his conceptualization of fluid (g*f*) and crystallized (g*c*) intelligence to provide a framework for cognitive development (Cattell, 1967). In his notion, fluid intelligence is defined as "an expression of the level of complexity of relationships which an individual can perceive and act upon when he does not have recourse to answer to such complex issues already stored in memory" (Cattell, 1987, p. 115). Crystallized intelligence in turn is defined as "expressions, though of a judgemental, discriminatory, and reasoning nature, [that] operate in areas where the judgements have been taught systematically or experienced before" (Catell, 1987, p.115). In his investment theory Cattell stated that initially only a general ability, called fluid ability, exists. It is "connected with the total, associational, neuron development of the cortex" (Cattell, 1987, p. 138). Fluid intelligence is content free and underlies all intellectual processes. In the course of development, fluid intelligence is formed and organized by the investment of motivation, the frequency of reward, and distal environmental influences. As a consequence of the so invested fluid abilities, crystallized intelligence emerges as the "fixed form" in different areas. Thus fluid abilities are the foundation and represent context independent, basic cognitive processes such as speed of processing and reasoning. They determine the basic capacity an individual is able to handle intellectually. The form in which this basic capability manifests itself, depends on the amount of time invested into acquiring knowledge, motivation, interests, but also on the perceived success and positive reinforcement of investing intellectual abilities (Cattell, 1987). Two individuals with identical scores on

measures of fluid intelligence could hence end up with crystallized knowledge in completely different areas as well as different levels of expertise in one area. This would then necessarily be ascribed to different distal and proximal environmental factors (see Hess, 2005). However, fluid and crystallized abilities are mutually dependent. The ability to understand and to learn complex and abstract new contents depends on the level of fluid intelligence of an individual. The ease of learning will in turn reinforce motivation and interest in fields where success is likely. Motivational aspects as well as fluid intelligence, hence, are both indispensable for intellectual development. As a result, fluid and crystallized intelligence will remain correlated although they reflect different stages and processes in the course of intellectual development. Successful cognitive development proceeds only with the interaction of crystallized and fluid abilities as well as distal and proximal environmental factors in any area in any individual (Cattell & Horn, 1978). Cattell emphasized the influence of experience, education and personal characteristics on cognitive development (1987). The effect of environment on cognitive development has, for instance, been shown in studies that found expertise and education compensating normative age-related decline (e.g., Masunaga & Horn, 2000). Empirically, both g*c* and g*f* in different stages of the life as well as the hypothesis of investment have been investigated across the lifespan. Although Cattell's investment hypothesis was developed to explain childhood development, parts of individual differences in changes in general knowledge are encouraged by differences in fluid abilities across the adult lifespan (McArdle, Hamagami, Meredith & Bradway, 2000). Additional empirical support for Cattell's conceptualization of g*f* and g*c* comes from studies on genetics: while age-related decline in g*f* was found to be largely genetic (70%) the opposite was true for g*c* for which 67% of change was attributable to environmental influences. These results serve as empirical evidence for the conceptualization of g*f* and g*c* across the life span (McArdle, Prescott, Hamagami & Horn, 1998).

In order to encompass the non-cognitive influences on adult knowledge, Ackerman (1996) further developed Cattell's investment theory into his Intelligence-as-process, personality, interest, intelligence-as-knowledge theory. He, very similar to Cattell's fluid intelligence, proposed one aspect of intelligence to be categorized as process. As tested in intelligence tests that assess maximal performance abilities, mainly the information-processing components are assessed. Information-processing contains components such as speed, reasoning, and memory span. These are also the components for which age-related decline is continuously found in ageing research (Verhaeghen & Salthouse, 1997). It is supposed to be rather biologically determined.

Ackerman stated that his definition of intelligence-as-knowledge "matches the first definition of Gc provided by Cattell in his Investment Theory" (Ackerman, 1996, p.241). He postulated, however, that his notion of intelligence-as-knowledge was much broader and that "there are probably as many domains of knowledge as there are occupations" (Ackerman, 1996, p. 241). This conceptualization of intelligence strongly emphasises the importance of environmental demands (e.g., Hess, 2005) and the considerable extent of idiosyncrasy in intelligence and intellectual development. Personality aspects, motivation, and interests then determine the orientation toward and the content of different knowledge domains an individual will engage in and try to gain knowledge and expertise (Ackerman, 1996, 2000; Rolfhus & Ackerman, 1999). Ackerman's theory explicitly aimed at providing a framework for understanding adult intellectual development and interindividual differences in intellectual development. He postulated that during childhood, institutionalization with accompanied common curricula would limit the amount of interindividual differences. Only with advancing diversity in academic and personal life, idiosyncrasies become more pronounced (Ackerman, 1996).

One assumption of the PPIK is that a more reliable way of assessing intellectual performance in order to infer the general intellectuality of an individual is to measure typical rather than maximal performance. Maximal performance describes the assessment of an individual's maximal capability ideally independent from context and content (Ackerman, 1994). Typical performance can be described analogous to stable personality traits. Hence, typical performance describes what an individual is most likely to do across different (intellectual) situations and across time (Ackerman, 1994). Maximal cognitive performance is an important research target in order to understand the basic mechanisms of intelligence (e.g., Lindenberger & Baltes, 1995). However, from a differential psychology perspective, typical performance described as "what a person is most likely to do" is equally important. Assessing intelligence from a typical-performance perspective makes the consideration of motivation, personality and interest mandatory (Ackerman, 1994; Kanfer, 1990). Also self-regulatory processes in the form of monitoring the necessities and demands of intellectual tasks and the knowledge of one's available resources and level of intellectual functioning are important in assessing the level and the mechanisms of long-term, everyday typical performance (cf., Ackerman, 1994). Hence, typical performance represents the level of functioning an individual is most likely to maintain and is eager to stabilize across time. In the course of development and changing environmental demands, an individual is likely to invest resources in order to preserve this stable level of functioning. Not the maximal capability of an individual in the presence of unusual challenges or tasks is of central interest, but the typical, reliable, and stable performance in environments and situations. The conceptualization of intelligence as typical performance calls for the description of an individual differences variable that explains differences in "typical" that are not accounted for by differences in maximal ability. To successfully manage the investment of engagement and the allocation of cognitive resources in order to maintain a stable level of typical functioning, metacognition

comes into play as an important mechanism to "supervise the intellective demands". One construct at the interface between abilities and personality is Typical Intellectual Engagement (Ackerman, 1994; Ackerman & Heggestad, 1997). It will be addressed in the next section in discussing Typical Intellectual Engagement (Goff & Ackerman, 1992); metacognition will be addressed subsequently in the paragraph on "metacognition" (1.3.).

1.2.1. Typical Intellectual Engagement, Need for Cognition, and Openness to Experience

Within the framework of Ackermans PPIK-theory (1996, 2000), Typical Intellectual Engagement (Goff & Ackerman, 1992) has been postulated as a construct to explain non-ability individual characteristics that influence typical performance. Typical Intellectual Engagement is defined as "an individual's aversion or attraction to tasks that are intellectually taxing" (Ackerman, Kanfer & Goff, 1995, p. 276). Typical Intellectual Engagement hence describes an individual's stable and enduring inclination to engage in intellectual activities. Goff and Ackerman (1992) conceptualized Typical Intellectual Engagement as a dispositional construct associated with intelligence as typical performance. Hence, Typical Intellectual Engagement can be seen as a trait-like construct that describes an individual's typical way of engaging in intellectual activities across situations, the orientation in terms of content being individually coloured by her own interests. Connecting Typical Intellectual Engagement to motivational aspects of learning, Typical Intellectual Engagement would be a trait-like aspect of individuals that generally rather adopt learning goal orientations over performance goal orientations. Learning goals describe cognitive activities that are linked to increase one's competence via task mastery without the necessity of demonstrating one's ability to others. Positive affect is associated with the engagement itself rather than the outcome (Kanfer, 1990). The alignment to learning goals might hence be regarded as an important underlying mechanism that influences an individual's aversion or

attraction towards the engagement in cognitively challenging activities in her leisure time (see also Matzler & Mueller, 2011; Vermetten, Lodewijks & Vermunt, 2001). Across the lifespan, Typical Intellectual Engagement should influence the amount of acquired knowledge and should be related to g*c* (e.g., Dellenbach & Zimprich, 2008). Typical Intellectual Engagement could explicitly represent in part the motivational person characteristics that have already been addressed in Cattell´s investment theory. The extent to which an individual invests motivational resources in knowledge acquisition is hence dependent on the level of Typical Intellectual Engagement. Two individuals with the same level of fluid abilities but different levels of Typical Intellectual Engagement should consequently be different with respect to quality and quantity of possessed knowledge. The difference, however, is driven by differences in the motivational equipage rather than differences in true intellectual capacity. According to the so called fan spread phenomenon (e.g., Stanovich, 1986), interindividual knowledge differences should become stronger. Also, the influence of Typical Intellectual Engagement on g*c* should increase across the lifespan. While in childhood and early adolescence institutional effects predominantly influence knowledge acquisition, in later stages of the lifespan those formal, and for all individuals equal, influences are diminished. More and more, personal idiosyncrasies exert their influence on development. Hence, the relation between levels of Typical Intellectual Engagement and acquired knowledge should increase.

Typical Intellectual Engagement has been found to be closely related to Openness to Experience (Costa & McCrae, 1995) and Need for Cognition (NFC; Cacioppo & Petty, 1982). While Ackerman and Goff (1994; Goff & Ackerman, 1992) explicitly formulated the expected relation to the Big Five personality trait Openness to Experience, they did not mention the conceptual closeness to NFC. In what follows, Typical Intellectual Engagement will be juxtaposed to Openness to Experience and NFC.

Within the conceptualization of the Big Five personality traits, Openness to Experience describes individuals that are intellectually curious, aesthetically sensitive, high in need for variety, and liberal in their value systems (Costa & McCrae, 1992, p. 660). In the hierarchical structure of Openness to Experience, the following subordinate facets have been postulated: Fantasy, Aesthetics, Feelings, Actions, Ideas, and Values (Costa & McCrae, 1992). While generally a relation between Openness to Experience and Typical Intellectual Engagement has been reported in many studies (Arteche, Chamorro-Premuzic, Ackerman & Furnham, 2009; Rolfhus & Ackerman, 1999; Rocklin, 1994; Zimprich, Allemand & Dellenbach, 2009) this relation especially holds true for the facet Openness to Ideas (Ackerman & Goff, 1994; Mussel, 2010). Conceptually, Typical Intellectual Engagement and Openness to Experience delineate constructs. However, while Openness to Experience describes a rather stable, outlasting disposition that impinges on a wide variety of situations and behaviours, Typical Intellectual Engagement is restricted to activities that are related to intellectual activities and knowledge acquisition. Studies have shown the incremental validity of Typical Intellectual Engagement after controlling for the influence of Openness to Experience on intellectual performance (Chamorro-Premuzic, Furnham & Ackerman, 2006b). Hence, in order to gain insight into person characteristics that can explain interindividual differences in knowledge and intellectual functioning, the more specific construct of Typical Intellectual Engagement seems to be more precise and, hence, better suited than the broad, with regard to content, non-specific personality factor Openness to Experience. The facet Openness to Ideas more specifically describes an individual's tendency to the active pursuit of intellectual interests and the engagement in new, unconventional ideas. The facet has been found to be related to g*f* (Moutafi, Furnham & Crump, 2006). Typical Intellectual Engagement has been proposed to mediate the relation between knowledge and personality. Containing intellectual motives the deliberate allocation of

resources to acquire new knowledge and engaging in intellectual activities might, thus, more strongly depend on Typical Intellectual Engagement (Ackerman et al., 1995; Moutafi et al., 2006). Openness to new ideas would hence describe the scope within which an individual is curious and intellectually flexible. The motivational foundation to actual engage in intellectual activities, however, would be better described by the measured intensity of Typical Intellectual Engagement.

In the same vein, Typical Intellectual Engagement and NFC (Cacioppo & Petty, 1982) have been found to be conceptually and empirically related. NFC describes the motivation of an individual to make sense of the surrounding world by means of thinking and problem solving. Individuals, low in NFC, tend to rely on others to make sense for them (Cacioppo, Petty, Feinstein & Jarvis, 1996; Fleischhauer et al., 2010). Some researchers have argued that both constructs are basically the same, finding correlations as high as $r = .78$ (Mussel, 2010; Woo, Harms & Kuncel, 2007). On the contrary, ForsterLee (2007) found evidence that Typical Intellectual Engagement differentially predicted performance in men and women, whereas NFC has repeatedly found to be gender neutral (Cacioppo & Petty, 1982; Spotts, 1994). Additionally, NFC is represented by one single dominant factor (e.g., Sadowski, 1993). Some studies did find a multifactor solution; however, it has been questioned if the subscales provide any differential information (see Cacioppo et al., 1996). For Typical Intellectual Engagement, in turn, several reliable subscales have been found in different studies (Dellenbach & Zimprich, 2008; Ferguson, 1999; Wilhelm, Schulze, Schmiedek & Süss, 2003). Hence, although sharing a large amount of variance, NFC and the different subfactors of Typical Intellectual Engagement apparently are different (see Wilhelm et al, 2003).

In the present thesis, the construct of Typical Intellectual Engagement is chosen over NFC for the reason of Typical Intellectual Engagement being implemented in a

comprehensive framework of cognitive development in adulthood (Ackerman, 2000, 1996). Because the main aim of the present thesis is to add some knowledge to the literature on cognitive development across the lifespan, a construct that can be directly linked to a theory on cognitive development in adulthood seems to be appropriate. However, one needs to bear in mind, that both constructs are conceptually as well as empirically similar (Mussel, 2010; Woo et al., 2007).

1.3. Metacognition

Having discussed the possible influence of Typical Intellectual Engagement as a proximal factor in the course of adult intellectual development, in what follows I will elaborate on a different aspect, namely the role of metacognition. High levels of cognitive functioning have been postulated to be an important aspect of subjective well-being (Lawton et al., 1999) as well as successful aging (e.g., Kahn, 2002; Rowe & Kahn, 1997). The definition of successful ageing as "older individuals' lifestyle choices that would maximize their own likelihood of aging well and maintaining a high quality of life in old age" (Kahn, 2002, p. 726), stresses the importance of cognitive functioning. In turn, impending cognitive decline poses a great risk of decreasing well-being on individuals (Price et al., 2011). Cognitive functioning can, to a certain extent, be influenced by an individual itself (Hultsch et al., 1999; Schaie, 1984). In terms of successful ageing, the influence of genetic factors was postulated to decrease and the influence of nongenetic factors such as lifestyle choices increase (Ackerman, 1996; Cattell, 1987; Kahn, 2002; Rowe & Kahn, 1997). This has not only been discussed in the field of successful ageing, but also at the other end of the continuum in the field of slowing down pathological cognitive decline (Hultsch et al, 1999; Scarmeas, Levy, Tag, Manly & Stern, 2001). However, to be able to choose to engage in

(cognitive) activities makes self-regulatory and metacognitive monitoring processes mandatory.

Metacognition is defined as "cognition about cognition" (Hertzog & Hultsch, 2000, p. 417). This broad concept subsumes different aspects. Hertzog and Hultsch (2000) subdivided metacognition into three categories: 'The knowledge about cognition and cognitive functions in general; the monitoring of the current state of the cognitive system; and the beliefs an individual holds about her own cognitive abilities and that of others ' (Hertzog & Hultsch, 2000, p. 417). The beliefs individuals hold about cognition has been further subdivided into implicit theories about cognitive ageing and self-referent beliefs about cognition. While the former describes general beliefs an individual holds about general ageing processes, the latter explicitly refers to ageing processes an individual experiences herself (Hertzog & Hultsch, 2000). The first category contains declarative knowledge about the general functioning of cognition and cognitive functions and, opposed to this, the processes that are categorized in the second group contain operations that monitor and analyze "current state information" on current cognitive operations during learning. The third category contains implicit and explicit beliefs about one's own cognitive abilities and that of others. Stereotypes about memory functions are as well inherent in this category as the grown experience with one's own cognitive capabilities across time.

Although all categories have been linked to cognitive functioning (e.g., Rabbitt & Abson, 1991; Rast & Zimprich, 2009) and deserve attention in the course of cognitive ageing, in the present thesis I will focus on beliefs about memory and especially on beliefs an individual holds about her own performance. Self-reported beliefs mirror the self-rated ability of one's own performance. In the course of discussing subjective aspects that influence cognition, beliefs about one's own functioning seem to be most informative when conducting research on interindividual differences in cognitive ageing. In order to obtain information

about how an individual evaluates her own cognitive abilities, the concentration on subjective beliefs about one's own memory seems, hence, to be the most suited option. The use of self-reports has been described as "a source of data that can be related to other empirical observations and thereby can help investigators draw inferences about the participants' psychological processing" (Nelson, 1996, p.103). Thus, self-reported cognitive evaluations represent a valuable source of information when examining interindividual differences in cognitive development across the adult lifespan. Although rather in the context of monitoring current cognitive operations, Nelson (1996, 2002) has described metacognition as one way to empirically assess awareness and aspects of self-regulation. This idea does also apply to evaluating one's own cognitive capabilities in the broader framework of typical performance. Implicit theories that picture cognitive abilities as malleable are related to learning goal orientations and self-efficacy (Kanfer, 1990; Matzler & Mueller, 2011; Vermetten et al., 2001). Although only moderately accounting for variance, research has shown that self-efficacy and cognitive performance are significantly related. In their study, Valentijn et al. (2006) found that memory self-efficacy explained approximately 3% of variance in a verbal learning task. Moreover, the authors report that low memory self-efficacy was related to less improvement in sequential trials of a verbal learning task (η^2 = .57). Hence, beliefs an individual holds about her own cognitive functioning are not only an important aspect of self evaluation but are also related to actual cognitive performance (Caretti, Borella, Zavagnin & De Beni, 2011). Generally, research that examined the relation between reported and actual memory performance has repeatedly found correlations not exceeding r = .3 (cf., Cavanaugh & Poon, 1989; Jorm, Christensen, Korten, Jacomb & Henderson, 2001; Valentijn et al., 2006). The question that, hence, arises is why those relations are repeatedly found to be as low as they are. Various explanatory approaches have been promoted.

It has been suggested that beliefs about memory functioning are a function of general beliefs, self-efficacy and control that act rather independently from cognitive performance (e.g., Bandura, 1989). Although subjective beliefs do influence performance (Caretti et al., 2011) the accuracy with which performance is evaluated might not be most important. It seems possible that the mere conviction that one is able to fulfil a certain task influences the effort an individual invests and, hence, the outcome (e.g., Cavanaugh & Green, 1990). Hertzog and Hultsch (2000) stated that implicit theories may influence the recalling of a past cognitive personal status and that expectations that are derived from implicit theories may also influence future cognitive performance. However, these evaluations may be biased due to time passing and other personal characteristics that work on the accuracy of memory.

In the same vein, another line of research has argued that memory ratings are rather a function of personality traits and affect (Jylhä, Melratin & Isometsä, 2009; Kliegel & Zimprich, 2005; Metternich, Schmidtke & Hüll, 2009). Depression as well as neuroticism in healthy adults may strongly influence the level of self-rated cognitive abilities (Mol, Ruiter, Verhey, Dijkstra & Jolles, 2008). This line of argument comprises that the relation between subjective and objective memory performance is important, however, it seems as if the perceived capability not necessarily depends on objective capability, but rather on emotionally transmitted impressions of how one's own performance is believed to be. It is known from research on depression that cognitive biases can strongly influence behaviour and well-being even if the cognitive representations of situations or abilities are not grounded on actual events, but rather on individual interpretations of those (e.g., Lester, Mathews, Davison, Burgess & Yiend, 2011).

A third line of research that has dealt with explaining the small relation between memory performance and self-evaluated memory performance often found has focused on psychometric aspects (Herrmann, 1982). Measurement instruments differ in content and

rating formats as much as individuals differ in their way of evaluating their own performance (e.g., Albert, 1977; Arnkelsson & Smith, 2000; Brown & Middendorf, 1996). This line of reasoning advocates that even if subjective and objective cognitive performance were reliably related, the inaccuracies in measurement instruments and individual differences would prevent a reliable assessment of both constructs. Although the reliability of the instruments has proven acceptable (e.g., Hertzog, Dixon & Hultsch, 1990; Hertzog, Park, Morrell & Martin, 2000), the question of interindividual differences in rating behaviour endures. Related to this, Martin and Zimprich (2003) and Zimprich, Martin and Kliegel (2003) proposed that the relation between subjective and objective cognitive measures should be assessed longitudinally, because then those interindividual differences in rating behaviour could be controlled for.

To summarize, metacognition has been recognized as an important factor of cognitive development. However, different explanatory approaches in combination with a manifold of inconsistent results exist concerning the relation between objective and subjective cognitive performance. Further research is needed to clarify the relation between objective and subjective cognitive performance ratings and the function of subjective ratings with respect to objective performance. Future research could engage in investigating the relation between the two constructs from different perspectives. This could include different methodological approaches or examining the relation between subjective and objective cognitive performance in different groups of individuals with different cognitive statuses. Both approaches would further investigate the relation between the constructs within the framework of assuming that a reliable relation between the constructs exists. Yet a different approach for future research could lie in further examining the purpose of subjective cognitive evaluations in the course of managing one's own cognitive development.

1.4. Examining change in lifespan developmental research

Before embarking on discussing the research questions of the present thesis, in this chapter I will briefly discuss the examination of change in developmental research and will briefly address the concept of measurement invariance (MI; Meredith, 1993; Meredith & Horn, 2001; Meredith & Teresi, 2006). According to Meredith (1993), testing MI is an explicit method to ensure that characteristics of the applied instrument remain stable across groups or time. Only with MI established on the level of manifest indicators, inferences can be drawn from the results on the latent level that are not biased by the instrument (Meredith & Horn, 2001). A possible problem if not testing for measurement invariance is that items could be comprehended differently across groups or at different measurement occasions (Meredith, 1993). By explicitly testing MI, one can assure that "the linear composites assumed to measure a given set of concepts in different groups, or at different times, are indeed measuring those concepts in the same way in the different circumstances" (Meredith & Horn, 2001, p. 206). For developmental research this implies that with MI the foundations are laid to study true development whilst keeping the psychometric characteristics of an instrument constant. Hence, MI reflects whether the measurement characteristics remain unaffected by time or in different groups and change or differences can be reduced to true changes or differences in the underlying theoretical concept (but see Nesselroade, Gerstorf, Hardy & Ram, 2007, on dynamic factor analysis).

One way to examine the different degrees of measurement invariance lies in applying confirmatory factor analyses (Lubke, Dolan, Kelderman & Mellenbergh, 2003; Meredith, 1993; Meredith & Horn, 2001; Meredith & Teresi, 2006). Another approach is originated in item response theory (IRT; Reise, Widaman & Pugh, 1993). Generally, in item response theory, functions are derived that try to account for "the relation between [the] examinee level on a latent variable and the probability of a particular item response" (Reise et al., 1993,

p.557). In IRT, statistical models that specify the conditional probability of an individual to response in a particular response category of one item are derived. Measurement invariance in IRT is even stricter than within the framework of confirmatory factor analyses, because equality constraints are imposed on the probability of responding to the particular categories. Establishing measurement invariance hence implies that the item functions unbiased, that is individuals at the "same latent level have the same expected probability of response regardless of group membership" (Reise et al., 1993, p. 560). Violations to measurement invariance, in turn, are reflected in differential item functioning (DIF) and indicate that, dependent on group membership, individuals have systematically different probabilities to respond to specific item categories. However, in this thesis, the confirmatory factor analyses approach is chosen and, hence, will be described in more detail in what follows (see Lord, 1980, for an extensive introduction to IRT).

The factor analytic model with non-zero means of manifest and latent variables is specified as follows in a multigroup factor model:

$$\mathbf{y}_g = \boldsymbol{\tau}_g + \boldsymbol{\Lambda}_g \boldsymbol{\eta}_g + \boldsymbol{\delta}_g \tag{1}$$

where $\mathbf{y}$ denotes observed scores, g = 1,2,…G indicate groups, $\boldsymbol{\tau}$ represents a vector of intercepts, $\boldsymbol{\Lambda}$ is the factor loading matrix, $\boldsymbol{\eta}$ is the vector of scores on the latent variables, and $\boldsymbol{\delta}$ is the vector of residual terms.

Hence, the variance-covariance matrix can be derived:

$$\boldsymbol{\Sigma}_g = \boldsymbol{\Lambda}\, \boldsymbol{\Psi}_g\, \boldsymbol{\Lambda}'_g + \boldsymbol{\Theta}_g \tag{2}$$

where Σ denotes the covariance matrix of the items, Ψ denotes the covariance matrix of the factors, and Θ denotes the variances and covariances of the residuals. The mean structure that is also needed to test for measurement invariance can be expressed in the following equation:

$$\boldsymbol{\mu}_g = \boldsymbol{\tau}_g + \boldsymbol{\Lambda}_g \boldsymbol{\alpha}_g \tag{3}$$

where $\boldsymbol{\alpha}$ denotes the mean vector of a factor in group *g*.

Measurement invariance is a matter of degree and different levels can be described as will be shown below. According to Meredith (1993), the highest degree of measurement invariance can be expressed in:

$$(\mathbf{y}_i \mid \boldsymbol{\eta}_i, g) = \quad (\mathbf{y} \mid \boldsymbol{\eta}) \tag{4}$$

where $\mathbf{y}$ and $\boldsymbol{\eta}$ denote observed scores and factor scores, respectively and *g* denotes group membership. Equation (4) states that if measurement invariance holds then $\mathbf{y}$ as a function of $\boldsymbol{\eta}$ is equal across groups. In other words, measurement invariance implies that given a subjects factor scores $\boldsymbol{\eta}$, the subjects observed scores $\mathbf{y}$ do not depend on group membership, that is no bias of group membership exists.

The most basic level of MI is *configural invariance*, which implies that the same items indicate the same factor in each group or across time (Meredith & Horn, 2001). Without configural invariance to hold, items may be subscribed to different factors, indicating that the conceptualization of the items is ambiguous. The next level is *weak invariance*, which implies that the factor loadings of the items can be constrained to be equal across groups or time. In other words, $\boldsymbol{\Lambda}$ in (2) and (3) is constrained to be equal across groups or time (Meredith & Horn, 2001). If weak invariance holds, this indicates that the

proportion of how items contribute information to the assessment of the latent factor remains unchanged. Factor (co-)variances can be compared. On the next level, *strong invariance* is usually tested, implying that the intercepts are invariant across time or groups, that is $\boldsymbol{\tau}_g$ (in (3)) are constrained to be equal (Meredith & Horn, 2001). Conceptually this describes that no significant level differences exist between groups that are not attributable to the underlying latent construct (Bollen, 1989). Factor means can be compared with strong measurement invariance. Eventually, *strict invariance* implies equal residual variances across groups or time, that is, $\boldsymbol{\Theta}$, are constrained to be equal across groups or time (Meredith & Teresi, 2006). With strict measurement invariance to hold, all changes in variances on the latent level are attributable to changes in the latent construct since error variances are equal across groups or time (Chen, Sousa & West, 2005).

Because change is ubiquitous in development, not one but several different aspects of change are of interest in developmental research, namely changes on the group level as well as changes of individuals (Martin & Zimprich, 2005; Nesselroade, 2001; Zimprich & Mascherek, 2010). To meet this criterion it is necessary to analyze data sets from different perspectives and to include different dimensions along which changes can occur. In what follows I will briefly address structural change, absolute change, change of divergence, differential change, and specific versus general change (Allemand, Zimprich & Hertzog, 2007; Martin & Zimprich, 2005).

Structural change refers to the persistence of the covariance pattern between factors across groups or time (Martin & Zimprich, 2005). It describes whether the relation of variables of a given construct remains the same. In research on cognition, structural change is referred to as differentiation and dedifferentiation, where differentiation implies lower and dedifferentiation higher interfactor correlations (Zimprich & Martin, 2010). Although structural change mainly refers to the relation between established factors, it still is a matter

of degree and contains the different degrees of measurement invariance (Allemand et al., 2007; Meredith & Horn, 2001).

Absolute change refers to the mean change of a construct across time or groups. It conceptually describes how a construct changes on average (Allemand et al, 2007; Martin & Zimprich, 2005). A second aspect describing the trajectory or differences on group level is change of divergence. *Change of divergence* refers to the question whether interindividual differences change across time. Is the average range becoming wider, smaller or does it remain the same across time or groups (Zimprich & Mascherek, 2010)? Change of divergence hence describes the homogeneity or heterogeneity of a construct within a group. An increase in variances implies individuals drifting apart. Hence, change of divergence hints at interindividual differences in development; however, it not necessarily implies differential change (see below). Although mean level changes and changes in divergence are informative in terms of an average (maybe normative) progression, note that individual trajectories might deviate from those predicted by absolute change and change of divergence.

Differential change refers to possible changes in rank-order between individuals. Differential change is a measure to assess individual changes across time. It can only be assessed longitudinally (Allemand, Zimprich & Martin, 2008; Martin & Zimprich, 2005). Changes in rank-order conceptually imply that some individuals change to a smaller (or larger) amount than others. Differential change indicates that the trajectory of the construct under study is different for different individuals.

A last aspect of change refers to *general versus specific change* (Allemand, Zimprich & Martin, 2008). This aspect describes the generality of change in a given construct, hence addresses the question whether an underlying mechanism can be ascribed to the change in different (sub)-factors (Martin & Zimprich, 2005). Empirically, general versus specific change is assessed in correlating longitudinal change scores in the constructs. If changes are

highly related, this would suggest that one underlying mechanism could be responsible for the observed change in the different factors. General change denotes a necessary, however, not sufficient condition to infer that one underlying mechanism might drive change in two or more related constructs.

Only if all five aspects of change are considered in an analysis of development, a detailed picture concerning changes on group and individual level can be drawn. For developmental research, investigating change from different perspectives allows for gaining insight in different mechanisms underlying development. For instance, normative and nonnormative changes in individuals could be disentangled. While strong mean-level changes (i.e., absolute change) are rather linked to normative changes, rank-order changes hint at stronger nonnormative, individual changes. Because both types of change can occur independently, it is mandatory to investigate both in order to shed light on the different mechanisms that underlie possibly observed change. If rank-order changes would be observed in Typical Intellectual Engagement, it is plausible to assume that changes observed are caused by nonnormative influences. If, however, only mean-level change would occur, the conclusion that Typical Intellectual Engagement was strongly dependent on biological mechanisms and could not easily be influenced would be more adequate. Hence, investigating change from different angles enables inferences about the basic developmental characteristics of a construct. In the next chapter I know turn to the description of the questions addressed in the current work.

1.5. The current work

Research examining the influence of non-cognitive influences on cognitive-development has yielded varying results and leaves a number of questions unanswered. Thus, we aim at further investigating the development of person characteristics that influence

cognitive development such as Typical Intellectual Engagement (1.2.; *Study 1* and *Study 2*) and the relation between subjective and objective cognitive performance (1.3; *Study 3* and *Study 4*) across the adult lifespan. The present thesis is thus divided into two parts. Both parts are concerned with non-cognitive aspects of cognitive development in adulthood; however, two slightly different approaches are taken. In this chapter, the two broad research questions will be formulated and presented.

First, above and beyond the influence of changes in cognitive variables on cognitive development, several proximal and distal personal factors also need to be taken into account in order to establish a comprehensive lifespan theory on cognitive development (cf., Ackerman, 1996; Cattell, 1987; Scarmeas & Stern, 2003; Schooler, 1984). Environments surrounding an individual (Hess, 2005; Schooler, 1984) and aspects within an individual such as personality, interests, and motivation, contribute to and influence the developmental trajectory of cognitive functions. Within the limit of biological boundaries, cognitive ageing seems to be open to the deliberate control of an individual. Inferring from these theoretical considerations, Goff and Ackerman (1992) proposed Typical Intellectual Engagement as one important person characteristic that contributes to the development of knowledge and that might explain interindividual differences in cognitive ageing over and above differences in cognitive ability. Typical Intellectual Engagement is conceptually located among personality and intelligence and is significantly related to knowledge acquisition and academic achievement as a proxy for knowledge (Goff & Ackerman, 1992; Rolfhus & Ackerman, 1999). As outlined above, Typical Intellectual Engagement is thought to influence the direction and the extent of knowledge acquisition and, hence, cognitive development in general (e.g., Chamorro-Premuzic, Furnham, & Ackerman, 2006a). It has also been outlined that, although postulated as a rather stable person characteristic (Goff & Ackerman, 1992),

Typical Intellectual Engagement is prone to experiences and motivational influences (e.g., Ackerman et al., 1995; Kanfer, 1990).

Having discussed the relation between Typical Intellectual Engagement and cognitive development, the question arises: How does Typical Intellectual Engagement itself develop across the adult lifespan? No research has been conducted yet to address this question. Before the mutual development of both constructs can be investigated, Typical Intellectual Engagement itself needs to be studied further in a developmental context itself. Also, knowledge of the developmental trajectory of Typical Intellectual Engagement may provide additional information that could facilitate the positioning of the construct at the intersection of motivation, intelligence, interest, and personality. This is what *Study 1* (2.1.) and *Study 2* (2.2.) of the present thesis aim at. *Study 1* investigates age-related differences in Typical Intellectual Engagement cross-sectionally in young and old adults to gain large scale information about Typical Intellectual Engagement. While this helps to draw a picture of Typical Intellectual Engagement in a lifespan scope, no inferences can be drawn about the individual from cross-sectional research. Age differences between young and old individuals should not be interpreted as reflecting ageing effects within an individual (e.g., Hofer & Sliwinski, 2001). Additionally, in cross-sectional data, cohort effects and many years of systematic environmental influences cannot be controlled for, leading to possibly biased results. Still, cross-sectional data sets are a useful tool in developmental research, because large age differences can be covered and, thus, assumptions about the possible development of a construct can be made, provided that measurement invariance is established.

In order to complement the cross-sectional results of *Study 1*, in *Study 2* the development of Typical Intellectual Engagement is investigated longitudinally across five years. Therefore, inferences can be made about the development of Typical Intellectual Engagement within an individual. Additionally, idiosyncrasies that might act as confounding

variables in cross-sectional data can be controlled for. Taken together, covering both, the large age difference in *Study 1* in order to learn more about Typical Intellectual Engagement in young and old adults and the longitudinal findings in *Study 2* to be able to make inferences about developmental trajectories and individual differences, represents a sound approach for understanding the development of Typical Intellectual Engagement across the adult lifespan.

Investigating the development of Typical Intellectual Engagement across the adult lifespan will allow gaining an understanding of the trajectory of the construct. This allows for reliably relating Typical Intellectual Engagement to trajectories of cognitive abilities and further investigation of the influence of Typical Intellectual Engagement on knowledge acquisition. So far, the relation has only been studied in cross-sectional studies (Dellenbach & Zimprich, 2009) but, to the best of our knowledge, no one has investigated the mutual influence. However, in order to do so and to draw reliable conclusion, the development of Typical Intellectual Engagement itself needs to be understood. *Study 1* and *2* will contribute to this understanding and will provide a developmental framework within which the developmental dependency of cognitive abilities and Typical Intellectual Engagement could further be investigated. Additionally, the studies allow disentangling different components of Typical Intellectual Engagement. Depending on the trajectory, inferences can be made whether Typical Intellectual Engagement is stronger grounded in personality or motivation. Hence, *Study 1* and *2* will provide empirical evidence for the theoretical conceptualization outlined in 1.2.1.

Second, if cognitive development is partly influenced by the individual's amount of engagement in (cognitively) challenging activities, then one central prerequisite is the ability to reliably evaluate one's own functioning. Deliberate attempts to expediently engage more or less in (cognitive) activities to maintain a desired level of functioning depend on the ability to monitor one's own performance. Engagement as such is not necessarily linked to precise

self-evaluation. However, in order to expediently manage the investment of cognitive activities in order to maintain a satisfactory level of functioning, efficient self-evaluation seems to be an important aspect.

In *Study 3* (3.1.) we address the question of "What do cognitive reports reflect?" in a group of either healthy, mildly cognitive impaired or demented clinical outpatients. Are cognitive complaints closely related to affect or do they reliably reflect cognitive losses? We hypothesize that investigating this question in a group of memory clinic outpatients should be especially informative. In an experimental setting the accuracy of judgements has been found to increase in older adults with increasing meaningfulness of the task (cf., Hess, Rosenberg & Waters, 2001). Also, in older individuals, concerns with age-related losses in abilities are more salient and hence easier accessible (e.g., Weiss & Lang, in press). Both aspects should apply to a group of individuals seeking help due to perceived problems in memory functioning. As a group of individuals prone to cognitive change, self evaluation of one's own cognitive performance should be highly relevant and, hence, salient and easily accessible. Additionally, in a group of individuals that are in part objectively impaired in cognitive performance, cognitive complaints can be addressed concerning their potential differentiating role at different stages of levels of functioning. The results of *Study 3* will, hence, allow inferences about the relation between subjective and objective cognitive performance in differently cognitively impaired groups. This will help understanding whether for different cognitive levels self-evaluations of cognitive functioning serve different purposes or are differentially accurate or important for different functional levels.

Study 4 (3.2.) also addresses the question of "What do cognitive complaints reflect?", however, a rather methodological approach to the topic is taken. It is argued that and investigated whether the relation between self reported and objectively measured memory performance is better assessed in looking at commonalities in change across time (see also

Zimprich et al., 2003). We hypothesize that assessing the commonality in change results in a stronger correlation between the constructs. This would indicate that the purpose of subjective ratings might rather be that of detecting deviations than to assess absolute performance levels. In order to understand the relation between objective and self-rated cognitive performance, it might be helpful to focus on the commonality in change rather than on the performance and the rating at a static, given time point. Having data that cover a time span of 12 years, enough change variance in both variables should emerge to enable reliable modelling of parallel change trajectories. From the results of *Study 4* we will learn whether the repeatedly found small relation between subjective and objective cognitive evaluations is due to confounding individual differences that cannot be controlled for in cross-section. If this was the case, the change correlation should be significantly larger than the level correlation. If the change correlation would remain low this would indicate that either variables that have not yet been taken into account influence the relation or that the purpose of the relation between subjective and objective cognitive performance is to manage cognitive functioning through the monitoring or allocation of cognitive resources that are not precisely linked to the reliable self-evaluation of measurable objective functioning. It seems possible that intentionally allocating and monitoring resources would be restricted to domains that are of special importance to the maintenance of subjective well-being. Because the importance of different domains could be different between individuals, the relation between subjective and objective performance would not show to be large if subjective importance ratings would not be controlled for.

Altogether, in the present thesis a variety of approaches are taken to investigate different aspects of non-cognitive influences on cognitive development across the adult lifespan. The four studies will be introduced in more detail now.

2. THE DEVELOPMENT OF TYPICAL INTELLECTUAL ENGAGEMENT ACROSS THE ADULT LIFESPAN

In this chapter, two studies will be presented that investigate the development of Typical Intellectual Engagement across the adult lifespan in detail. While in *Study 1* Typical Intellectual Engagement is examined in a cross-sectional design, in *Study 2* Typical Intellectual Engagement is investigated longitudinally across 5 years.

2.1. Age related differences in Typical Intellectual Engagement between young and old adults[1]

2.1.1. Introduction

A construct filling the gap between personality and intelligence was put forth by Goff and Ackerman (1992). They postulated "Typical Intellectual Engagement" to describe specific aspects of personality that are closely related to intelligence. Typical Intellectual Engagement has been defined as "a personality construct that represents an individual's aversion or attraction to tasks that are intellectually taxing" (Ackerman et al., 1995, p. 276) Thus, it is believed to be related to acculturative and purposeful development and expression of certain intellectual abilities. Typical Intellectual Engagement illustrates that people differ with respect to their breadth of interests and their need for deeper understanding of complex issues. For example, one person may spend several hours a day reading and thinking, whereas another person may prefer sports or socializing. Typical Intellectual Engagement exemplifies these differences with respect to the degree of engagement in intellectual activities in leisure time or in job performance and academic achievement (Chamorro-Premuzic, Furnham & Ackerman, 2006b; Wilhelm et al., 2003).

[1] A similar version of this chapter has been accepted for publication in "Experimental Aging Research" (Mascherek & Zimprich, in press)

Measurement of Typical Intellectual Engagement

Based on the theoretical construct of Typical Intellectual Engagement, Ackerman and Goff (1994) developed a selfrating scale to measure Typical Intellectual Engagement. The original questionnaire entails 59 Items. A number of studies have applied an abridged version with item selection being unique to each study (e.g., Dellenbach & Zimprich, 2008; Wilhelm et. al, 2003). The Typical Intellectual Engagement scale measures differences in individual interests and engagement in intellectual activities. The Typical Intellectual Engagement scale as a whole can be divided into several different subfactors. Depending on the study, items have been assigned to different subfactors, for example, Reading, Abstract Thinking, Problem Solving, Intellectual Curiosity, Intellectual Avoidance, or Contemplation (Ackerman & Goff, 1994; Ferguson, 1999; Dellenbach & Zimprich, 2008; Wilhelm et. al, 2003). Referring to the structure found by Dellenbach and Zimprich (2008), the present study postulates a four factor structure with the factors Reading, Abstract Thinking, Problem Solving, and Intellectual Curiosity. All four factors describe different aspects of Typical Intellectual Engagement. Reading aims at the quantity and quality of books a person reads, containing items such as “I read at least ten books a year”. Abstract Thinking captures interest in philosophical issues and contains items such as “You are philosophical inclined, that is, inclined to philosophize about things.” Problem Solving aims at the aspect of engaging in thinking about elaborate theoretical issues and contains items such as “I really enjoy a task that involves coming up with new solutions to problems.” The fourth factor, Intellectual Curiosity, covers the more motivationally driven aspects of Typical Intellectual Engagement and contains items such as “I really enjoy a task that involves coming up with new solutions to problems”.

Typical Intellectual Engagement and personality

To place Typical Intellectual Engagement within the field of personality-intelligence research, the question of empirical relations to personality has to be addressed. Generally, Typical Intellectual Engagement is described as a highly stable trait-like a facet of personality (cf., Ackerman & Goff, 1994; Goff & Ackerman, 1992; Gow, Whiteman, Pattie & Deary, 2005) and is conceptually linked to the BIG Five personality trait Openness to Experience. In validation studies, examining different samples, significant correlations (r = .65, $p < .05$) between Typical Intellectual Engagement and Openness to Experience emerged repeatedly (Ackerman & Goff, 1994). More specifically, Ackerman and Goff (1994) showed that the correlations between Typical Intellectual Engagement and Openness to Experience are mainly based on an overlap with the facet Openness to Ideas. Ferguson (1999) found that the strongest associations among single Typical Intellectual Engagement subfactors and Openness to Experience emerged for abstract reasoning, a subdimension of Typical Intellectual Engagement (r = .54, $p < .001$). Additionally, he found that Typical Intellectual Engagement and Openness to Experience put different stress on personal agencies. He correlated Typical Intellectual Engagement with measures of internal control beliefs and found a statistically significant relation (r = .37, $p < .001$) whereas Openness to Experience remained statistically unrelated (r = .20, $p > .05$) to internal control beliefs. Additionally, Paunonen and Ashton (2001) showed that measuring narrow personality traits is a better predictor for academic achievement than taking the broad factor as an indicator and here, again, Typical Intellectual Engagement is more precise. Taken together, the construct of Typical Intellectual Engagement reveals aspects of personality that are not encompassed by other well established personality traits but rather contributes specific information that is helpful for the process of understanding the personality - intelligence interplay.

Typical Intellectual Engagement and Intelligence

In the following we will address the empirical relations between Typical Intellectual Engagement and intelligence. Correlations with crystallized intelligence measures were repeatedly found to be substantially higher than with fluid intelligence measures (Verbal Ability r = .49, $p < .05$, Math r = .12, n.s.; Ackerman et al, 1995; see also Furnham & Chamorro-Premuzic, 2006; Zimprich et al., 2009). In a study conducted by Ackerman (2000), a significant positive correlation ($r = .29$, $p < .05$) between Typical Intellectual Engagement and crystallized intelligence emerged. In a meta-analysis of personality - intelligence relations, Ackerman and Heggestad (1997) identified Typical Intellectual Engagement and Openness to Experience as the two personality traits being correlated with knowledge and achievement. The relations between Typical Intellectual Engagement and intelligence are thus mostly accounted for by measures of knowledge and crystallized intelligence.

A possible explanation for the relations between Typical Intellectual Engagement and crystallized intelligence is provided by Cattell's investment hypothesis. According to this hypothesis, knowledge accumulation has to be considered in a larger context of non-ability traits such as personality, motivation and interests (Cattell, 1987). The amount of time and effort an individual invests in knowledge acquisition is more driven by motivation and personality than fluid ability. Ackerman (1996) further developed Cattell's investment hypothesis into his PPIK. He postulated that interindividual differences in interests and motivation account for interindividual differences in knowledge. Ackerman proposes that abilities determine the probability of success, and personality and motivation determine the amount of effort an individual puts into attempting a special task. Hence, personality and motivation may explain differences in adult intellectual competence where ability cannot account for those differences (Chamorro-Premuzic et al., 2006b).

Both theories aim at providing a substantial framework in which the development of individual differences in knowledge can be understood. However, although Typical Intellectual Engagement has been recognized as an important influence on the development of knowledge (e.g., Furnham, Swami, Arteche & Chamorro-Premuzic, 2008; Gow et al., 2005; Rolfhus & Ackerman, 1999; Wilhelm et al., 2003), the development of Typical Intellectual Engagement itself has not been addressed so far. Additionally, most existing research has been done on samples of undergraduates (e.g., Chamorro-Premuzic et al., 2006b; 2006a), whereas Typical Intellectual Engagement in old has not been addressed yet (for an exception see Dellenbach & Zimprich, 2008). Hence, the aim of the present study was to study the structure of Typical Intellectual Engagement in young and old adults.

Types of change and differences in personality development

In research on development, different types of change can be examined, namely, absolute differences, differences in variances, structural differences, differential change, and general versus specific change (see Allemand et al., 2007; Martin & Zimprich, 2005). Differential or rank order and general versus specific change can only be examined longitudinally. As the present study deals with cross-sectional data, we concentrate on absolute differences, differences in variances and structural differences. In the following, we briefly outline the concept of each type of change and present relevant literature. Generally, research on the different types of change is sparse. Concerning Typical Intellectual Engagement, to the best of our knowledge, no comprehensive studies exist; hence, we present research on personality concerning the different types of change.

Absolute differences. Research concerning the mean-level structure refers to the stability of an absolute quantity of an attribute across groups or over time. Although it is the most commonly used measure to investigate change or differences across time or age groups it mainly is the least informative as it masks individual changes over time because changes

are only assessed on average (Martin & Zimprich, 2005). Mean-level changes in Openness to Experience most often have been found in terms of a decline into old age (Caprara, Caprara & Steca, 2003; Helson, Kwan, John & Jones, 2002; McCrae et al., 1999; Roberts, Walton & Viechtbauer, 2006). In their comprehensive meta-analysis, Roberts et al. (2006) found significant decline in Openness to Experience in the age range from 60-70. No change was found for the age range from 22-60. Allemand et al. (2007) found results indicating into the same direction. Examining the Big Five Personality traits in a middle aged (42-46 years) and an old aged (60-64 years) sample in a 4-year interval each, they found significantly lower values for Openness to Experiences in the old, both cross-sectionally and longitudinally. Hence, we expect mean-level differences pointing towards less Typical Intellectual Engagement in the old for the following reasons. First, literature on mean-level decline in personality is quite consistent. Second, as Typical Intellectual Engagement exhibits a close relation to cognition as well, and here mean-level changes are also found, we assume, that the part accounting for the relation, might drive decline in Typical Intellectual Engagement in old age (e.g., Ackerman & Heggestad, 1997; Rolfhus & Ackerman, 1999; Salthouse, 1991).

Differences in divergence. Research on differences in divergence among groups aims at interindividual differences within a given construct. Empirically, change of divergence is assessed by examining the variances across groups or time (Martin & Zimprich, 2005). Conceptually, greater variance implies greater heterogeneity; small variance implies homogeneity with respect to interindividual differences of personality traits. The only studies that examine differences in variance reveal inconsistent results. Small, Hertzog, Hultsch and Dixon (2003) report no change in variances in the BIG Five personality traits across a 6 year period in older adults. In contrast, Allemand, Zimprich and Martin (2008) report an increase in variance with respect to Openness to Experience over a 12-year period in older adults. Taken those results together, one may conclude that differences in variance do occur across

lifespan, but in order to assess change of divergence in personality traits one needs to observe a substantial time interval. Hence, inferring from the studies presented above we expect to find an increase in interindividual variability as, although cross-sectionally, our data cover an age range of almost 50 years.

Structural differences. Research on structural differences in personality traits refers to the positioning of the different traits relative to each other across groups. Empirically, structural continuity is assessed by examining the covariation patterns across age groups (Caspi & Roberts, 2001). Most studies examining the covariance structure among personality traits, either longitudinally or cross-sectionally, report substantial stability (e.g., Robins, Fraley, Roberts & Treszniewski, 2001). Using the NEO-PI, Small et al. (2003) found structural stability in a sample of 474 adults (ranging from 55 to 85 years) across a 6-year period. Examining cross-sectional data, Allemand, Zimprich and Hendriks (2008) found structural stability in all age groups (N = 2.494, six groups, ranging from 16-91 years). One contradictory finding is reported by Allemand, Zimprich and Martin (2008). They found structural change in the personality traits of the NEO-FFI across a 12 year period in an old-aged sample (N = 300, 60-64 years at first measurement occasion). Covariances between Extraversion and Conscientiousness, between Openness and Conscientiousness and between Agreeableness and Conscientiousness increased significantly across the 12-year period. Due to the fact that mainly structural stability of personality is reported we expect to find structural stability, that is no differences in the covariance structure of Typical Intellectual Engagement between young and old adults.

To summarize, in the present study we concentrate on differences between young and old adults concerning absolute differences, differences in divergence and structural differences in Typical Intellectual Engagement. Relying on the results of studies on Openness to Experience, we expect to find substantial differences in the mean-level structure for all

four subfactors, namely less Typical Intellectual Engagement in the old, and differences in divergence, namely an increase in interindividual variability in the old, whereas we expect to find substantial structural stability across groups.

2.1.2. Method

Participants

The total sample of the present study comprised 832 participants, divided into two age groups. The subsample of older adults entailed individuals from the Zurich Longitudinal Study on Cognitive Aging (ZULU; Zimprich et al., 2008), an ongoing study on normative cognitive aging in Switzerland. The subsample comprised 364 participants in the age range of 65-80 years (for details of sample recruitment and sample composition see Zimprich et al., 2008). Participants were on average 72.99 years old (SD = 4.4 years), 46% of the participants were female. On average, participants had 12.8 years (SD = 3.0 years) of formal education. The young participants of the present study were undergraduate students from the University of Zurich. The subsample comprised 468 participants in the age range of 18-25 years. Participants were on average 21.12 years old (SD = 1.8 years), 69% of the participants were female. In terms of representativeness, both, the old and the young subsample, were more educated in comparison to the general population of persons of the same age. The comparison between the groups in the present sample still seems warranted, because the young sample was at the very beginning of their university training (i.e., 12.9 years of education on average), which matches the average 12.8 years of education in the old group.

Measures.

All analyses refer to an abridged version of the Typical Intellectual Engagement scale investigated by Dellenbach and Zimprich (2008). It contains 16 out of the 59 original items. Item selection was based on factor analyses of previous studies dealing with the structure of Typical Intellectual Engagement. By tendency all studies involved young, well educated

student samples, although the age range did include some older adults and some less educated persons, respectively. Across the different studies items with the highest factor loadings were selected (for details see Dellenbach & Zimprich 2008). The scale entails four related subfactors with four items each: Reading (e.g., I read a great deal), Problem Solving (e.g., I enjoy thinking out complicated problems), Abstract Thinking (e.g., Sometimes I like to consider concepts even if they may be of no practical con sequence), and Intellectual Curiosity (e.g., There are very few topics that bore me). Except for the factor Intellectual Curiosity, four items each were assigned to each subfactor. Item 1C ("I maintain I lively interest in reading books on a variety of topics") was allowed to load on intellectual curiosity as well as reading. Cross-loading was allowed as the item's phrasing comprised aspects that fit both for reading and intellectual curiosity. Subjects were asked to answer the items on a 5-point-Likert-scale ranging from 1 (strongly disagree) to 5 (strongly agree). High scores then indicate a high interest in engaging in intellectual demanding activities. Two items had to be reversed for data analyses. The factorial structure consists of four intercorrelated first order factors. The subfactors with their four related items each and their corresponding means and standard deviations for each group are presented in Table 1.

Table 1. *Descriptive Statistics of Typical Intellectual Engagement Items for Young and Old*

	Mean Young	SD Young	Mean Old	SD Old
Reading				
TIE1A*	3.60	1.05	3.16	1.31
TIE1B*	3.74	.99	3.93	1.07
TIE1C	3.29	.95	3.35	1.15
TIE1D*	3.53	1.32	3.10	1.56
Problem solving				
TIE2A (R)*	3.53	1.06	3.74	.98
TIE2B*	3.15	.84	2.90	1.02
TIE2C*	3.48	.90	3.26	1.17
TIE2D	3.20	.98	3.22	1.1
Abstract thinking				
TIE3A*	3.74	1.18	3.15	1.35
TIE3B (R)*	3.35	1.18	2.95	1.28
TIE3C	3.47	.96	3.38	1.11
TIE3D*	3.84	1.08	4.08	.77
Intellectual curiosity				
TIE4A*	3.52	.85	3.91	.95
TIE4B*	2.65	1.0	3.72	1.25
TIE4C*	3.17	1.05	3.75	.95
TIE4D*	3.59	.84	3.79	1.08

Note: * = group differences $p < .01$; N for Young = 468, N for Old = 364; all items were answered on a 5-point Likert-type scale ranging from 1 (strongly disagree) to 5 (strongly agree); TIE = Typical Intellectual Engagement; (R) = reversed Items

Statistical Analyses

Four degrees of measurement invariance were examined by constraining different parameters to be equal across the two groups. According to Meredith and Horn (2001) the following different forms of measurement invariance were imposed on the dataset: configural invariance, weak factorial invariance, strong factorial invariance, and strict factorial invariance. Analysis of measurement invariance was conducted as a prerequisite to provide a valid basis for examining absolute differences, differences in divergence, and structural differences on the latent level. Without establishing measurement invariance, emerging differences could also be due to differences on manifest level as well, hence, causing difficulties in interpretation. Analyses on the latent level were conducted using confirmatory factor analysis. Means and variances were also included into the analyses to model interindividual differences.

As criteria for model fit, the Comparative Fit Index (CFI), and the Root Mean Square Error of Approximation (RMSEA) are reported. Values of the CFI above 0.90 denote a well fitting model, whereas for the RMSEA values less than 0.06 may be interpreted as indicating good model fit (Hu & Bentler, 1999). In addition, we report χ^2-values, degrees of freedom (*df*), and corresponding *p*-values for all models examined. Model parameterization and factor scaling of the configural invariance model were achieved by fixing the factor variances to one and the factor means to zero. These constraints were relaxed, depending on the model specified and its identification status. Specifically, after having established partial strong factorial invariance (see below) across age groups, those constraints were only retained for the young age group, the reference group, whereas for the old age group, factor means and factor variances were freely estimated. The estimated factor means and variances then represent relative values or differences that have to be interpreted in comparison with the reference group. Note that due to the unbalanced sex ratio in our young and old sample, we statistically controlled for sex throughout the analyses. Throughout the analyses we use SPSS 17 and Mplus version 3.0 (Muthén & Muthén, 2004).

2.1.3. Results

Measurement Invariance

We started model building with a Configural Invariance Model of the four correlated Typical Intellectual Engagement-factors Reading, Problem Solving, Abstract Thinking and Intellectual Curiosity where for both groups the same four manifest variables served as an indicator of each latent factor. By constraining which item loads on which factor to be equal across groups, one can test whether the general composition of the specified factor is equal across the two tested groups. As Table 2 shows, the model achieved an acceptable fit concerning the CFI and RMSEA (CFI = 0.93, RMSEA = 0.051). Although the χ^2-value indicated a significant departure of the model from the data, we accepted the model as an

adequate description. We did so because the residuals for the covariance matrices exhibited small departures on every item but no pronounced departures on specific items. So the conclusion seems warranted that the overall fit of the model was acceptable and the degree of misfit represented general "background noise".

Table 2. *Estimated Models*

Model	χ^2	*df*	$\Delta\chi^2$	Δdf	CFI	RMSEA	90% CI
Model without grouping	320.128	92			0.92	0.055	0.048 - 0.061
Configural Invariance	395.064*	189			0.93	0.051	0.044 - 0.058
Weak MI	439.897*	202	44.833*	13	0.92	0.053	0.046 - 0.060
Strong MI	600.346*	214	160.449*	12	0.87	0.066	0.060 - 0.072
Partial Strong MI[b]	480.122*	211	40.225*	9	0.91	0.056	0.049 - 0.062
Strict MI	590.268*	226	110.146*	16	0.88	0.062	0.056 - 0.068
Absolute stability[b]	619.141*	214	139.019*[a]	4[a]	0.87	0.067	0.061 - 0.074
Stability of Divergence[b]	525.710*	214	45.588*[a]	4[a]	0.89	0.059	0.053 - 0.066
Structural stability[b]	525.338*	216	45.216*[a]	6[a]	0.89	0.059	0.052 - 0.065

*$p < .01$, [a] represents the difference to Model Partial Strong MI; [b] intercepts of TIE1B, TIE2A, TIE3D were freely estimated for both groups; CFI = Comparative Fit Index; RMSEA = Root Mean Square of Approximation; CI = Confidence Interval of RMSEA;

We then tested for weak factorial invariance (Model weak MI), implying that the factor loadings of the items on the latent variables remained stable across groups. In constraining factor loadings to be equal across groups, one can test if the relative relation of the items remains the same. As can be seen from Table 2, this led to a significant reduction in model fit in terms of χ^2 differences compared to the model of configural invariance. According to Cheung and Rensvold (2002) the CFI and RMSEA still indicate an acceptable fit (CFI = 0.92, RMSEA = 0.053) and therefore we accepted weak measurement invariance, as sample size was large and χ^2-values become more sensitive for any deviation with increasing sample size. Inspection revealed as a source of the loss of fit a general

"background noise". This means that no specific parameters accounted for the loss of fit but rather that the model as a whole represented the data relatively worse. This seems reasonable as the model implies stronger constraints on the data set. Table 3 shows the unstandardized and standardized factor loadings for the measurement model. Note that parameter constraints act on covariance level. Standardized factor loadings can be different in numbers although equality constraints do hold, because of the standardization.

In a third step, we imposed strong factorial invariance (Model strong MI) by requiring the intercepts of the manifest variables to be equal across groups. By constraining intercepts to be equal across groups, one can test for if systematic differences on the intercept level exist between the groups. As can be seen from Table 2, again, model fit was reduced significantly in terms of χ^2-differences compared to model weak MI. This time, CFI and RMSEA changed as well, implying a significant decrease in fit (CFI = 0.87, RMSEA = 0.053). Upon inspection, we estimated three intercepts freely (namely, item TIE1B, TIE2A, TIE3D) as those items were closely related to activities our young sample carried out on a daily base and therefore confound the requirements of their study activities and true intellectual engagement. After allowing the critical items to be freely estimated we accepted partial strong factorial invariance across groups as, albeit, the differences in χ^2 indicated a significant decrease in model fit, CFI and RMSEA were within an acceptable range (CFI = 0.91, RMSEA = 0.056). According to Byrne, Shavelson and Muthén (1989) testing for differences on factor level is reasonable with partial strong measurement invariance as long as model specification includes multiple indicators and at least one measure is invariant. As we had four indicators for each factor with only one free item intercept in three factors, the criteria for interpreting differences on latent level are met in our model.

Table 3. *Unstandardized and standardized factor loadings for the measurement model*

	Unstandardized Factor loadings	Standardized Young	Standardized Old
Reading			
TIE1A	0.68	0.67	0.67
TIE1B	0.61	0.63	0.72
TIE1C	0.55	0.56	0.61
TIE1D	0.83	0.63	0.75
Problem solving			
TIE2A (R)	0.32	0.31	0.49
TIE2B	0.33	0.40	0.52
TIE2C	0.57	0.61	0.76
TIE2D	0.51	0.54	0.74
Abstract thinking			
TIE3A	0.56	0.50	0.62
TIE3B (R)	0.46	0.40	0.53
TIE3C	0.54	0.59	0.72
TIE3D	0.29	0.29	0.54
Intellectual curiosity			
TIE4A	0.41	0.49	0.53
TIE4B	0.42	0.43	0.45
TIE4C	0.35	0.34	0.43
TIE4D	0.46	0.54	0.57
TIE1C	0.28	0.29	0.28

Note: Factor loadings refer to the Model weak factorial invariance. Standardized factor loadings can be different in numbers although equality constraints do hold, because of the standardization; (R) = reversed Items

In a last step concerning measurement invariance, we tested for strict factorial invariance, that is constraining the residuals of the manifest variables to be equal across groups. As can be seen from Table 2, this model did not achieve an acceptable fit, implying that strict factorial invariance does not hold across groups. Differences in χ^2 and the CFI and RMSEA imply a substantial decrease in model fit in model strict MI (CFI = 0.88, RMSEA = 0.062). Hence, we used the partial strong factorial invariance model as a reference model throughout our further analyses.

Absolute differences

To test for absolute differences, that is factor-mean differences across groups on the latent level, factor means were constrained to be equal across groups. As can be seen from Table 2, this led to a profound reduction in model fit ($\Delta\chi^2 = 139.019$; $\Delta df = 4$, $p < .01$, CFI =

0.87, RMSEA = 0.067). Note that as factor means in the young group were set to zero as a reference, these estimates already reflect mean-level differences between young and old. Hence, at least one factor mean in the old group was significantly different from zero. When factor means were freely estimated based on the Model Partial strong MI, values were -.451 for Reading, -.705 for Problem Solving, -.837 for Abstract Thinking, and 1.495 for Intellectual Curiosity. Mean differences were all statistically significant ($p < .01$). As can be seen from Figure 1, the differences, expressed in Cohen's d, were of medium to large effect size. Old showed less Typical Intellectual Engagement in Reading (d = -.38), in Problem Solving (d = -.54), and Abstract Thinking (d = -.64), whereas in Intellectual Curiosity they exhibited substantially more Typical Intellectual Engagement (d = 1.04) than the young participants.

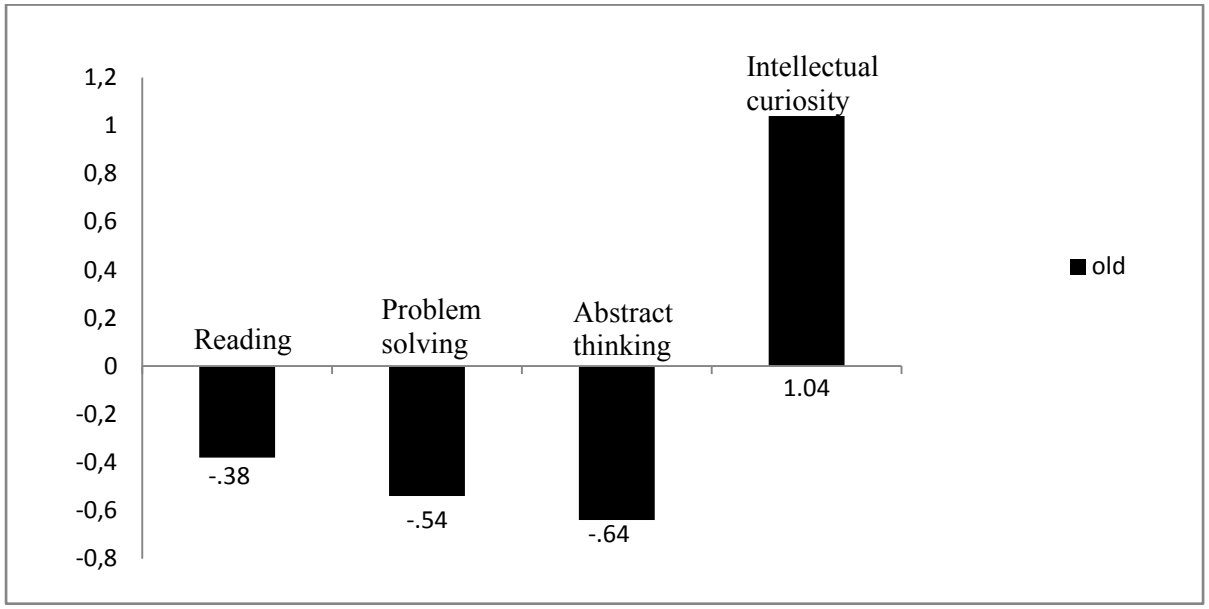

Figure 1. Mean-level differences expressed in Cohen's d
Note: all differences are significant on $p < .01$

Differences in divergence

To test for differences in divergence, that is differences in variance across groups, variances of Reading, Problem Solving, Abstract Thinking, and Intellectual Curiosity were constrained to be equal across groups. Stability of divergence would indicate that the young

and the old differ not substantially in terms of interindividual differences. As can be seen from Table 2 constraining variances to be equal across groups led to a significant reduction of model fit ($\Delta\chi^2 = 45.588$; $\Delta df = 4$, $p < .01$, CFI = 0.89, RMSEA = 0.059). Hence, at least one factor variance differed between the young and old. When factor variances were freely estimated based on model Partial strong MI, variances were 1.579 for Reading, 2.299 for Problem Solving, 1.846 for Abstract Thinking, and 1.424 for intellectual curiosity, respectively. As can be seen in Figure 2, variances in Reading ($\Delta\chi^2 = 11.805$; $\Delta df = 1$), Problem Solving ($\Delta\chi^2 = 29.279$; $\Delta df = 1$), and Abstract Thinking ($\Delta\chi^2 = 13.385$; $\Delta df = 1$) were significantly different ($p < .01$), whereas the difference in Intellectual Curiosity ($\Delta\chi^2 = 3.532$; $\Delta df = 1$) failed to reach statistical significance. These results reflect that, apart from Intellectual Curiosity, old participants were more heterogeneous than the young participants, thus exhibiting more profound interindividual differences in the old.

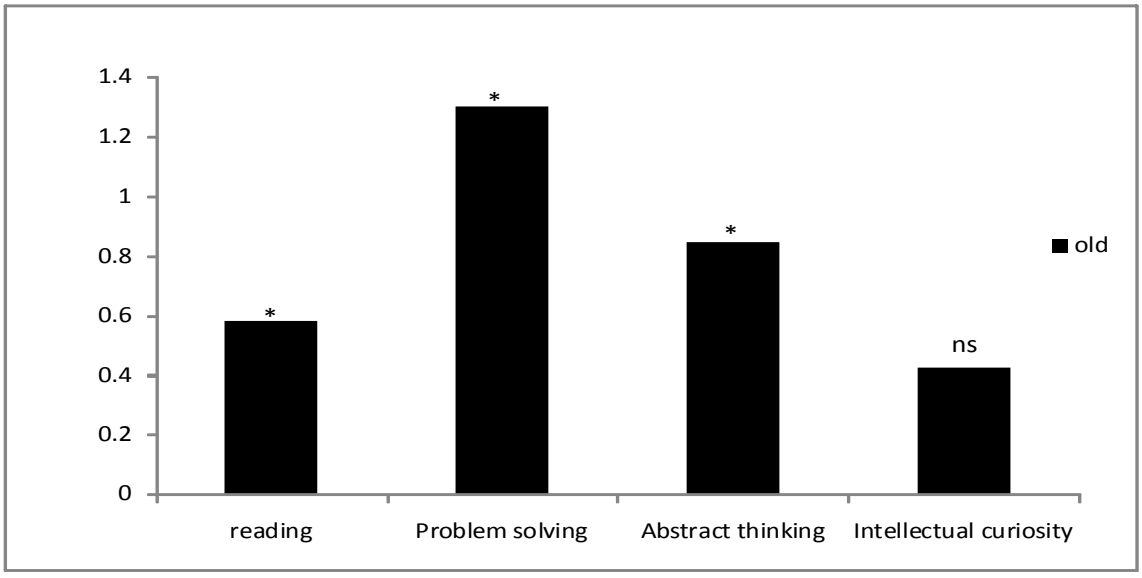

Figure 2. Differences in variances between young and old
Note: *p < .01

Structural differences

To test for structural differences, that is differences in covariances across groups, covariances among the factors on latent level were constrained to be equal across groups. We

report correlations because they can be interpreted in terms of effect sizes (see Table 4). However, models are estimated using covariances, because correlations depend on the variances of the factors. As the variances are significantly different between the groups, covariances are used to avoid a bias in the estimation process. As can be seen from Table 2, this model did not reach an adequate fit ($\Delta\chi^2 = 45.216$; $\Delta df = 6$, $p < .01$, CFI = 0.89, RMSEA = 0.059). Hence, at least one covariance had to be different across the two groups. As can be seen in Figure 3, the difference in reading/intellectual curiosity failed to reach significance, whereas all other five covariances among the four factors differed statistically significant between young and old participants ($p < .01$). Inspection revealed larger correlations in the old group. As can be seen from Table 4, correlations in the young group were only in the small to medium range ($r = .18$ to $r = .48$), except for abstract thinking/ problem solving ($r = .71$).

Table 4. *Factor correlations in young and old*

	Reading	Abstract Thinking	Problem Solving	Intellectual Curiosity
Reading		0.18	0.23	0.31
Abstract Thinking	0.44		0.71	0.48
Problem Solving	0.33	0.85		0.48
Intellectual Curiosity	0.37	0.72	0.68	

Note: Correlations in the lower triangle indicate old, Correlations in the upper triangle indicate young

In the old group, correlations ranged from medium to high level ($r = .33$ to $r = .85$), indicating stronger relationships among the four factors. Figure 3 shows that the effect of differences in correlations between young and old was medium in Problem Solving/Reading, Abstract Thinking/Problem Solving, Intellectual Curiosity/Problem Solving, and Intellectual Curiosity/Abstract Thinking. The difference in the correlation of Abstract Thinking/Reading revealed a large effect between young and old. The effect in Intellectual Curiosity/Reading

between young and old was very small, which is not surprising keeping in mind that the difference was nonsignificant.

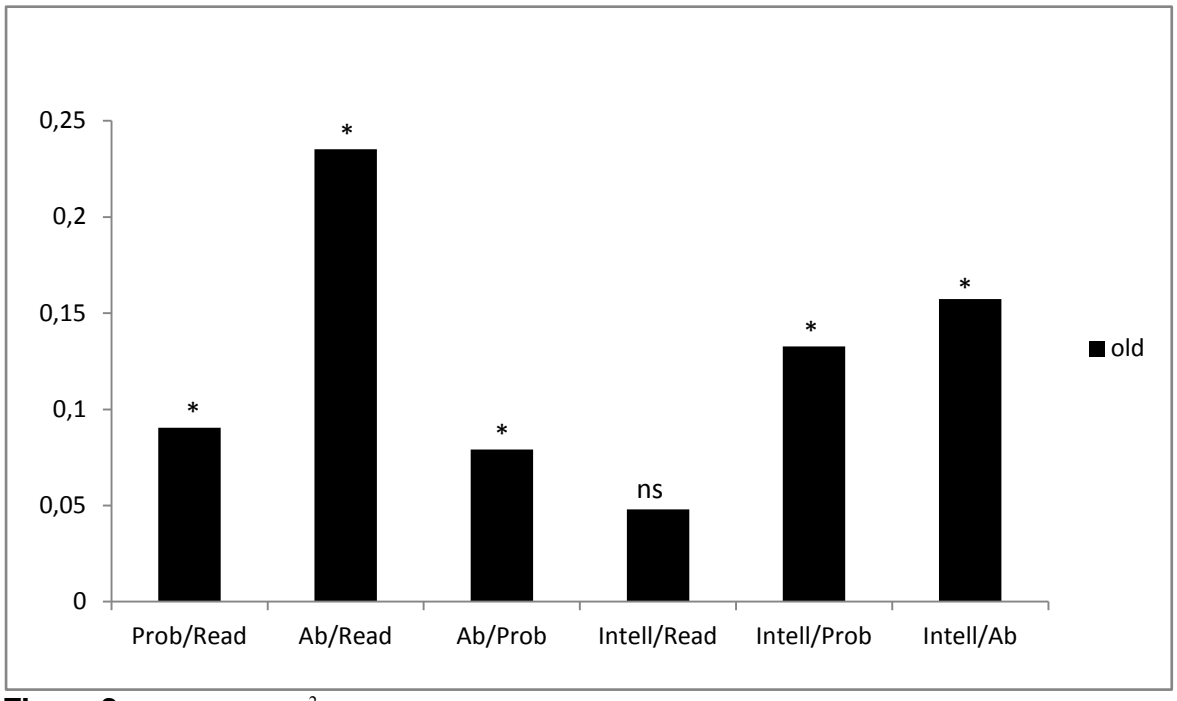

Figure 3. Differences in R^2 between young and old
Note: *p < .01

2.1.4. Discussion

The goal of the present paper was to analyze age-related differences between young and old adults in the means, the variability, and the structure of Typical Intellectual Engagement. We expected a significant mean-level difference in the four subfactors of Typical Intellectual Engagement indicating less Typical Intellectual Engagement in the old sample. Additionally, we expected greater heterogeneity within the old sample, which would manifest itself in significant differences in factor variances. A third aspect to address was the covariance structure of the four factors. Inferring from results on covariance structure in the big five personality trait, we expected structural stability, that is no differences in covariance structure to emerge between young and old adults. Note that in general, although we

statistically controlled for sex throughout our analyses, interactions between group and sex can be possible.

We began our analyses of the latent factor structure of the Typical Intellectual Engagement scale in testing different levels of measurement invariance. Configural and weak factorial invariance were established, implying that the four factor structure and the factor loadings of the corresponding items to each factor were equal across the two age groups. As a last step concerning measurement invariance, we established strong factorial invariance as a prerequisite for examining absolute differences, differences in divergence, and structural differences among groups. Only partial factorial invariance held. For an explanation note that with respect to the variance-covariance structure, the model is fitted to the data within groups, whereas, concerning the means, only between-group comparisons are possible. Hence, albeit the variance-covariance structure of the critical items reveals that within each of the two groups the model fits to a comparable degree, the mean structure of the four items reveals a reversed trend which needs further consideration for meaningful interpretation. The estimated intercepts for items TIE1B, TIE2A, TIE3D were higher for the old than for the young. Although from a methodological point of view analyses of differences on the latent level are allowed with partial factorial invariance established (Byrne et al., 1989; Reise et al., 1993) the exceptions are interesting from a conceptual point of view. We conclude that the wording of the items triggered an answering behaviour which referred to more motivationally driven aspects. This led to a different understanding of the items in contrast to the other items belonging to the respective factor. Considering the more motivationally driven aspects, the old sample exhibits more engagement than the young sample. This is not only reflected in the factor Intellectual Curiosity (see below) but is also present in the wording of some items.

We then addressed age-related differences on the latent level. First, to assess absolute stability (mean-level differences), the means of the latent factors were constrained to be equal

across groups. Statistically significant mean differences emerged for all four factors, ranging from medium to strong effect sizes. Reading, Problem Solving, and Abstract Thinking showed significant decline in the old, whereas in Intellectual Curiosity an increase in the old emerged. This findings hint towards a multidirectionality of the development of Typical Intellectual Engagement across the lifespan. The differences in Reading, Problem Solving and Abstract Thinking can be explained when arguing with cognitive resources that are involved. Reading in general requires a large amount of cognitive capacity for processing, hence becomes more exhausting in old age. Problem Solving and Abstract Thinking are more strongly related to fluid aspects of cognition such as processing speed for example. Although Typical Intellectual Engagement represents an aspect of personality rather than cognition, we assume that experiencing substantial decline in those cognitive domains leads to less engagement in intellectually taxing activities as they become more exhausting. Another possible explanation is related to the construct in social psychology of implicit theories that individuals hold about aging and memory influencing responses on self ratings (cf., Hertzog & Hultsch, 2000). Implicit theories are informal constructs held by individuals about specific psychological phenomena. In general, young and old adults tend to believe in cognitive decline in old age (Kite, Stockdale, Whitley & Johnson, 2005; McDonald-Miszczak, Hertzog & Hultsch, 1995). Hence, as Typical Intellectual Engagement is a self-reported measurement the results could be biased by the belief in decline in old age. The biggest factor-mean difference was shown in more Intellectual Curiosity in the old. Leaning on results concerning Openness to Experience, we expected a decline in all four factors. Hence, the results support Typical Intellectual Engagement as contributing detailed information concerning the personality/intelligence interplay. Conceptually, a higher level of Intellectual Curiosity is not to be explained as straightforward. According to Cattell (1987) and Ackerman (1996), motivational aspects account for intelligence performance and academic achievement as well

which are represented by intellectual curiosity in the Typical Intellectual Engagement scale. We conclude that the increase in Intellectual Curiosity reflects a lifelong interest in academic and/or intellectually taxing topics which may remain unaffected by age.

Certainly, when addressing developmental issues in a cross-sectional design one has to be aware that cohort effects or other systematic differences between the samples cannot be entirely controlled for. Hence, future research should also address Typical Intellectual Engagement in longitudinal designs, although this would make it difficult to obtain results that enable analyses with age differences of more than 50 years on average.

Second, stability of divergence was assessed. Factor variances were constrained to be equal across groups. Conceptually, decreasing variance implies increasing homogeneity, whereas an increase in variances implies a more heterogeneous sample with respect to the aspect under study. Variances in Reading, Problem Solving, and Abstract Thinking were significantly greater in the old, whereas the difference in variances of Intellectual Curiosity failed to reach significance. The results show that the group of old people was more heterogeneous in terms of intellectual engagement than the young subsample. Change of characteristics depends on lifelong experiences. People are attracted to environments that match their interests and meet their needs (e.g., Scarr & McCartney, 1983; Stanovich, 1986). Our results show that bigger differences between people, that is greater variances, occur in samples in which persons share less of the same environment. In a sample of undergraduates the proportion of shared environment is greater than it is in a sample of older people who had unique experiences across the lifespan. This assumption is met in the increase of factor variances in Typical Intellectual Engagement in the old. One limitation of the present study that is to be addressed here is that we have tested a rather homogeneous sample of young students in terms of education. Hence, the distinctiveness of the differences in variance could

be a sample artefact and differences could turn out smaller using a more representative young sample in terms of education.

Third, structural stability was assessed by constraining the factor covariances of the four factors to be equal across age groups. Except for Reading/Intellectual Curiosity, all covariances differed significantly between the two groups. Correlations among the four factors were higher in the old than in the young. Although in both groups all correlations are significantly different from zero, in the old they were more pronounced. We present two possible explanations. To our knowledge, no explicit theory concerning "dedifferentiation" in personality exists; therefore we borrow from cognitive theories. Dedifferentiation refers to the question whether a rather general factor underlies cognitive change in the old, that is to what degree changes in a single cognitive ability are associated with changes in other cognitive abilities. Dedifferentiation is shown in an increase of correlation as a function of age (e.g., de Frias, Lövdén, Lindenberger & Nilsson, 2007; Ghisletta & Lindenberger, 2003; Zelinski & Lewis, 2003). Despite existing controversial data concerning this theory (e.g., de Frias et al., 2007, for dedifferentiation; e.g., Tucker-Drob & Salthouse, 2008, for differentiation), we transfer this idea to the results of the present study. While the young are more specific, that is factor correlations are small, in development of the different aspects of Typical Intellectual Engagement, development of Typical Intellectual Engagement in the old appears to be more general, that is factor correlations are higher. Studies on the Five Factor Model of personality (Costa & McCrae, 1992; 1995) also exhibited increasing correlations among the factors across time (Allemand, Zimprich & Martin, 2008). We conclude that underlying processes may cause effects of dedifferentiation of personality characteristics. Note, that in the old, a second-order model with a "general Typical Intellectual Engagement" factor fitted the data well (see Dellenbach & Zimprich, 2008).We tried to fit a second-order model on the young subsample as well, but this did not achieve an acceptable fit.

Other than the limitations concerning the sample selection, one additional limitation pertains to the assessment of Typical Intellectual Engagement with only four items for each latent factor. Although the abridged version has been applied in previous studies, one has to bear in mind that four items provide limited information. Future studies may apply the original Typical Intellectual Engagement scale for replication.

Taken together, what do these results say about age differences in Typical Intellectual Engagement and about its structure? First, the results support the Typical Intellectual Engagement scale as being a valid contributor to the understanding of intellectual engagement, revealing more specific information than Openness to Ideas. Second, we found substantial mean-level differences between young and old. As the differences exhibit both increases and decreases in old age, the results give evidence to multidirectionality in terms of gains and losses in lifespan development. Third, we found evidence for increasing variance, that is greater heterogeneity within the old sample. This supports earlier work by Scarr and McCartney (1983) who postulate a close developmental relationship between choosing environmental settings that enhance one's own developmental potential concerning specific characteristics. As potentials are different in people, heterogeneity in the old is the stringent outcome. Fourth, borrowing from cognitive research and from results of the Five Factor Model, higher factor correlations are interpreted as dedifferentiation in Typical Intellectual Engagement in old adulthood. In future research the relation between Typical Intellectual Engagement and objective memory performance measures needs to be addressed to gain further understanding of how aspects of personality contribute to cognitive aging. For applied aging research this findings leave room for interventions training memory performance that take aspects of personality into account.

2.2. Stability and change in Typical Intellectual Engagement in old age across five years[2]

2.2.1. Introduction

The question of how one's own way of life and behaviour influence cognitive development and how non-cognitive aspects or environmental influences contribute to the development of cognitive performance has received increasing interest (e.g., Hertzog, 2009). A body of research, where mainly small to moderate effects are reported, exists on how intellectually demanding leisure activities, level of education, or complexity of occupation influence cognitive functioning (e.g., Schooler et al., 1999; Schooler & Mulatu, 2001; Schumacher & Martin, 2009). However, research on within-person variables that foster an intellectually engaged lifestyle is not as prominent yet.

Typical Intellectual Engagement

A construct that may help explain why some persons lead an intellectually engaged lifestyle was put forth by Goff and Ackerman (1992). They identified "Typical Intellectual Engagement" as a construct that is closely related to personality and to knowledge acquisition. Typical Intellectual Engagement is defined as "an individual's aversion or attraction to tasks that are intellectually taxing" (Ackerman et al., 1995, p. 276). Intellectually taxing activities may for example be reading or learning a new language. Research on cognitive aging has repeatedly found that engaging in intellectual activities can buffer cognitive decline in old age (Hertzog, 2009). Hence, Typical Intellectual Engagement could serve as one variable in explaining interindividual differences in cognitive development in old age.

A self-rating questionnaire is commonly used to assess Typical Intellectual Engagement. The scale can be divided into several different subfactors (Ackerman & Goff,

[2] A similar version of this chapter is currently in revision at the "Journal of Gerontology: Psychological Sciences" (Mascherek & Zimprich)

1994; Dellenbach & Zimprich, 2008; Ferguson, 1999; Wilhelm et al., 2003). According to Dellenbach and Zimprich (2008), Typical Intellectual Engagement can be subdivided into the four factors Reading, Abstract Thinking, Problem Solving, and Intellectual Curiosity. The different subfactors were found to be correlated with correlations ranging from r = .85 between Abstract Thinking and Problem Solving to r = .18 between Reading an Abstract Thinking (e.g., Mascherek & Zimprich, in press). Similar results have been found by Wilhelm et al. (2003).

To class Typical Intellectual Engagement with related concepts, Openness to Experience and Need for Cognition are closest. For the facet Openness for ideas correlations ranged from r = .44 to r = .70 for different subfactors of Typical Intellectual Engagement (Ackerman & Goff, 1994). However, Typical Intellectual Engagement still appears to add incremental validity: while cognitive abilities and the Big Five personality traits explained 15% of variance in academic performance, Typical Intellectual Engagement added a unique 9% of explained variance (Chamorro-Premuzic et al., 2006b). In the same vein, Typical Intellectual Engagement and need for cognition (NFC) (Cacioppo & Petty, 1982) have been found to be related with correlations as high as r = .78 (Mussel, 2010; Woo et al., 2007). However, ForsterLee (2007) found evidence, that NFC and Typical Intellectual Engagement differentially predict performance in men and women. Hence, although sharing a large amount of variance, NFC and the different subfactors of Typical Intellectual Engagement tap into different directions (see Wilhelm et al., 2003).

Concerning the relation between Typical Intellectual Engagement and cognitive variables, Typical Intellectual Engagement has been found to be differentially related to crystallized and fluid intelligence. While for fluid intelligence the relation was negligible (about 1% of shared variance), it was much stronger for Typical Intellectual Engagement and crystallized intelligence (about 11% of shared variance; Goff & Ackerman, 1992). These

findings were in line with the conceptualization of Typical Intellectual Engagement indicating that Typical Intellectual Engagement is related to volitional knowledge acquisition and study rather than to reasoning and speed. Using Typical Intellectual Engagement as a predictor variable for cognitive performance, Gow et al. (2005) found a small relation (r = .21; r = .13) between Typical Intellectual Engagement and IQ at age 11 and age 79. In a different study, Furnham et al. (2008) found a significant correlation between Typical Intellectual Engagement and general knowledge (r = .22) in a sample of 100 undergraduate students. ForsterLee (2007) showed that while Typical Intellectual Engagement was a significant predictor for cognitive performance in women, it was not in men. The relation between Typical Intellectual Engagement and education indicated that the higher the educational level of an individual the higher they score on Typical Intellectual Engagement (e.g., Wilhelm et al., 2003). Summarizing the existing literature, Typical Intellectual Engagement is one non cognitive variable for explaining interindividual differences in cognitive performance. Relations have repeatedly been found between Typical Intellectual Engagement and academic achievement on graduate level. However, besides the importance of Typical Intellectual Engagement for healthy aging, research on the development of Typical Intellectual Engagement and its relation to cognition in older age is sparse.

To the best of our knowledge, only one study investigated age-related differences in Typical Intellectual Engagement (see Mascherek & Zimprich, in press). But because Typical Intellectual Engagement was investigated cross-sectionally, no inferences can be made in terms of development and *inter*individual differences in *intra*individual change. Therefore, the objective of the present study was to examine different types of longitudinal change in Typical Intellectual Engagement across five years in an old aged sample. In what follows, we elaborate on five different types of change (cf., Zimprich & Mascherek, 2010), namely structural change, absolute change, change in divergence, differential change, and general

versus specific change. Because research on the development on Typical Intellectual Engagement is sparse we report results concerning Openness to Experience.

Structural change refers to the constancy of the subfactors' relation to each other. It describes to which extent the "skeleton" of the subfactors remains stable across time. Overall, results concerning structural change are mixed. Allemand, Zimprich and Martin (2008) found structural change in the Big Five personality traits across 12-years in old age. Contradictory to this finding, Small et al. (2003) found structural stability across six years. For Typical Intellectual Engagement, to the best of our knowledge only one study investigated structural stability cross-sectionally (Mascherek & Zimprich, in press). In their study they found structural differences between young and old adults with larger correlations between the subfactors for the older. Larger correlations between the Typical Intellectual Engagement subfactors would imply that differences between subfactors are diminished.

Absolute change, that is, change on the mean-level, refers to changes of a group of individuals. Mean-level changes in Openness to Experience most often have been found in terms of a decline in old age (Allemand, Zimprich & Martin, 2008; Allemand et al., 2007; Roberts et al., 2006). In their cross-sectional investigation of Typical Intellectual Engagement in young and old adults, Mascherek and Zimprich (in press) found both, higher and lower levels in the Typical Intellectual Engagement subfactors in old age. Results implied that while the manner in which intellectual activities are displayed was lower in old age, a general interest in academic and intellectually taxing topics was higher.

Change of divergence describes the change of interindividual differences with respect to a specific construct (e.g., Zimprich & Mascherek, 2010). It is expressed in increasing or decreasing variances and has been referred to as "fan-spread phenomenon" in the literature (Stanovich, 1986). Studies on change in divergence in personality development are sparse and with conflicting results. For Openness to Experience, Allemand et al. (2007) found larger

variances in younger adults compared to older adults. By contrast, Small et al. (2003) found stability of divergence for all Big Five personality aspects across six years. Yet another result has been found by Mascherek and Zimprich (in press) with respect to Typical Intellectual Engagement. They found significantly larger variances in the older sample compared to young adults for the subfactors Reading, Problem Solving, and Abstract Thinking. For Intellectual Curiosity, no difference was found.

Differential change reflects the consistency of individual differences across time (Martin & Zimprich, 2005). It describes to what extent individuals remain stable relative to each other. Over a 12-year period, Allemand, Zimprich and Martin (2008) found profound differential change, indicating individual differences in the change of personality traits. Across six years, Small et al. (2003) found high longitudinal differential stability for Openness to Experience. The results indicate that with elapsing time, individuals are more likely to change their relative placement within a reference group.

Specific versus general change refers to the question of the generality in change of the different Typical Intellectual Engagement factors (Martin & Zimprich, 2005). General change would indicate that changes in different factors can be ascribed to one underlying common mechanism. If the same underlying mechanisms drive the development of different aspects of Typical Intellectual Engagement, factors which appear different on behavioural level, must share structural commonalities. The opposite is true for specific change. Allemand, Zimprich and Martin (2008) found large commonalities in change between Openness to Experience, Agreeableness, Conscientiousness and Extraversion, indicating general change.

Overall, because the results reported mainly apply to Openness to Experiences, a related yet different construct, it is difficult formulate exact hypotheses. However, the following hypotheses were derived: First, mean-level stability as well as, second, structural stability were expected. Third, an increase in divergence was expected. Fourth, rank-order

coefficients were expected to resemble the relationship found in the study by Small et al. (2003), and, fifth, rather general than specific change was expected.

2.2.2. Method

Sample

The data for the present study come from the Zurich Longitudinal Study on Cognitive Aging (ZULU; Zimprich et al., 2008), an ongoing study on normative cognitive aging in Switzerland. At first measurement occasion (T1: 2005) the sample comprised 364 participants, whereas at the third measurement occasion (T3: 2010) 233 individuals participated in the study (for further details of sample recruitment and sample composition see Zimprich et al., 2008).The second wave was not included, because it was assessed 1.5 years after T1. A personality related construct such as Typical Intellectual Engagement would be expected to remain stable. To be able to capture change, we used data covering a time span of five years. Mean age at T1 was 72.99 years (SD = 4.4 years, 65-80 years) and at T3 was 77.90 years (*SD* = 4.42 years, 72-86 years) with 46% of the sample being female. In terms of representativeness, the sample of the present study was slightly overeducated (12.8 years of education on average). To examine whether sample attrition was selective, individuals leaving after T1 (26 individuals) and after T2 (104 individuals) were merged together into one group. There were no significant mean-level differences between the dropout and the non-dropout group. However, in the group of individuals that participated at all three measurement occasions, Typical Intellectual Engagement variances were significantly larger at T1. In addition, the covariances among the four subfactors were significantly higher in the non-dropout group. Although excluding individuals from the analyses limits the generalizability of the results, we only included the 233 complete cases, because change of divergence and structural change were of specific interest in the present study.

Measures

Typical Intellectual Engagement was assessed using a 16-items self-rating scale that was embedded in the ZULU-test battery. The 16 items represent an abridged version of the original 59-item Typical Intellectual Engagement scale (Ackerman & Goff, 1994). Item selection for the abridged version of the present study was based on previous factor analytic studies that examined the structure of Typical Intellectual Engagement (Ferguson, 1999; Goff & Ackerman, 1992; Wilhelm et al., 2003). Items with the highest factor loadings across the three studies were selected (for details see Dellenbach & Zimprich, 2008). The scale entails four related subfactors: Reading, Problem Solving, Abstract Thinking, and Intellectual Curiosity. Four items were assigned to each subfactor, except for the factor intellectual curiosity with five items. One Item ("I maintain I lively interest in reading books on a variety of topics") was allowed to load on Intellectual Curiosity as well as on Reading, because the item's phrasing comprised aspects that fit Reading and Intellectual Curiosity. Subjects were asked to answer the items on a 5-point-Likert-scale ranging from 1 (strongly disagree) to 5 (strongly agree). High scores indicate a high manifestation of Typical Intellectual Engagement.

Statistical Analyses

Measurement invariance was examined as a prerequisite for the analyses of different types of change on the latent level. Measurement invariance describes the degree of stability of the psychometric characteristics of a questionnaire. Changes on latent level can then be interpreted without cofounding measurement errors. Three degrees of measurement invariance were tested in the present analyses. We examined configural invariance, weak invariance and strong invariance. According to Meredith and Horn (2001), configural invariance implies constraining the items to load on the same factor across time indicating that the same items can be assigned to the same theoretical construct across time. Weak

invariance requires the factor loadings to be equal across time. This indicates that the information that every item contributes to the assessment of a construct, remains the same across time. Strong measurement invariance requires the item intercepts to be equal across time. Strong measurement invariance indicates that differences in latent factor means are not confounded by differences in item-specific intercepts (Meredith & Teresi, 2006). As criterion to evaluate changes in model fit we rely on changes in CFI. According to Cheung and Rensvold (2002), a drop of no more than .01 in CFI indicates invariance.

For the analyses of change in Typical Intellectual Engagement, first, structural stability was assessed by examining the invariance of factor covariances across time. Structural stability indicates that a construct and the relations between the subfactors remain stable across time. Next, differential stability was tested by assessing the test-retest correlation (Martin & Zimprich, 2005). Thirdly, mean level changes were assessed in constraining latent factor means to be equal across time. No significant decrement in model fit would indicate that on average, no change emerged. Change of divergence was then measured by constraining the factor variances to be equal across time. A significant decrease in model fit would imply that the sample became substantially more or less homogeneous. Hence, variances indicate the homogeneity of a sample. Finally, specific versus general change was assessed by correlating longitudinal change scores. For the analyses of change on the latent level, latent difference score models were applied (McArdle & Hamagami, 2001). As criteria for model fit, the root mean square error of approximation (RMSEA) with its 90% confidence interval, the comparative fit index (CFI) and the Root Deterioration per Restriction (RDR) are reported as fit indices. RMSEA values below .06 denote a good model fit and values up to .08 denote an acceptable fit, whereas for the CFI, values above .90 indicate a well fitting model (Hu & Bentler, 1999). RDR values below .08 can be interpreted as indicating no change in model fit (Raykov & Penev, 1998). Additionally, we report χ^2-

values, degrees of freedom, and corresponding *p* - values for all models. To scale the latent factors, factor means and variances were set to zero and one, respectively, to identify the model. The estimated means and variances for the change parameters should be interpreted in comparison to the estimates at T1. We used maximum likelihood estimation for our analyses. Analyses were conducted using SPSS 18 and SAS.

2.2.3. Results

Analyses started with specifying a four factor model separately for each time point. The model with the four factors Reading, Abstract Thinking, Problem Solving and Intellectual Curiosity, fitted almost equally well at both measurement occasions (see Table 5). This leads to the conclusion that longitudinal analyses of stability and change were warranted. Note that the errors of the manifest variables were allowed to be correlated across-time to improve model fit, and because in a longitudinal design, the same individuals are repeatedly measured, which implies that specific factors of the items can also be correlated across time. Then different degrees of measurement invariance were analyzed. The configural invariance model, evinced a good fit (Table 5). Second, we imposed weak measurement invariance. As can be seen from Table 5, this, in terms of fit indices (CFI = 0.99; RDR = .066; RMSEA = .049), did not lead to a decrement in fit. Hence, we accepted this model. Next, strong measurement invariance was tested for. This, again, did not lead to a significant decrease in model fit (CFI = 0.99; RDR = .056; RMSEA = .049); hence, we accepted the strong measurement invariance model. With measurement invariance to hold, changes on the latent level can be ascribed to changes in the underlying theoretical construct. They are not confounded by systematic changes in the responding behaviour.

Next, structural stability was analyzed. Constraining the covariances between the subfactors to be equal at T1 and T3 did not lead to a significant decrease in model fit ($\Delta\chi^2$ = 3.51, Δdf = 6, ns; CFI = 0.99; RDR = .000; RMSEA = .048). Structural stability was also

tested with constraining the interfactor correlations to be equal. In doing so, possible differences in factor variances are also taken into account. However, this did not alter the result (see Table 5, structural), indicating that the structure between the four factors was stable across a 5-year interval. The factors most strongly related were Abstract Thinking and Problem Solving (T1: r = .83; T3: r = .80), whereas the weakest relationship emerged between Reading and Problem Solving (T1: r = .25; T3: r = .24; see Table 6).

Table 5. *Estimated Models*

Model	χ^2	*df*	$\Delta\chi^2$	*df*	RDR	CFI	RMSEA	90% CI
4 factor T1	236.12	112			-	0.99	.069	.057-.081
4 factor T3	205.77	112			-	0.99	.060	.047-.073
Configural MI	735.71	480			-	0.99	.048	.041-.055
Weak MI	764.25	494	28.54*[a]	14[a]	0.066	0.99	.049	.042-.055
Strong MI	787.05	507	22.8*[b]	13[a]	0.056	0.99	.049	.042-.055
Structural	790.56	513	3.51[c]	6	0.000	0.99	.048	.042-.055
Differential	887.37	511	100.32*[b]	4	0.321	0.82	.060	.054-.066
LCS	787.05	507			-	0.99	.049	.042-.055
Absolute	795.87	511	8.83[c]	4	0.071	0.99	.049	.042-.056
Divergence	791.49	511	4.45[c]	4	0.021	0.99	.049	.042-.055

*p < .05; T1 = first measurement occasion; T3 = third measurement occasion; MI = measurement invariance; LCS = Latent change score model; [a] = represents the difference to the configural invariance model; [b] represents the difference to the weak MI model; [c] = represents difference to LCS; RDR = Root Deterioration per Restriction; CFI = Comparative Fit Index; RMSEA = Root Mean Square Error of Approximation; 90% CI = 90% Confidence Interval of RMSEA

To assess differential change across time, test-retest correlations were estimated for the factors. Perfect differential stability is indicated by a test-retest correlation of r = 1. To test this, a model with across time factor correlations being constrained to 1 was estimated. As Table 1 shows, this led to significant decrease in model fit ($\Delta\chi^2$ = 100.32, Δdf = 4, p < .05; RDR = .321; RMSEA = .060). The CFI dropped down to 0.82, implying that there were significant interindividual differences in the amount of change. At least for one subfactor the across-time correlation had to be less than r = 1. As can be seen from Table 6, although all subfactors showed rather strong differential stability, in sum, shifts in rank order emerged.

This result indicates that individuals differ in the amount of change in Typical Intellectual Engagement across five years. The individual developmental trajectories do not run parallel but are specific for different individuals. Mean-level change is independent from this construct.

Table 6. *Factor correlations*

	(1)	(2)	(3)	(4)
(1)Reading	**.88***	.43*	.25*	.26*
(2)Abstract Thinking	.37*	**.84***	.83*	.58*
(3)Problem Solving	.24*	.80*	**.83***	.65*
(4) Intellectual Curiosity	.26*	.67*	.66*	**.81***

Note: Correlations in bold indicate across time correlations; Correlations in the upper triangle indicate factor correlations at T1, correlations in the lower triangle indicate factor correlations at T3; * indicates correlations significantly different from zero on $p<.05$.

For the analyses of mean level changes, changes in variances and general vs specific changes, we reparameterized the strong measurement invariance model and estimated a latent change score model (LCS) (McArdle & Hamagami, 2001). Means and variances were fixed to 0 and 1, respectively in the level factor in order to identify the model. Hence, means and variances in the change factor can be directly interpreted as differences from the level estimates.

To test changes on the mean level, all factor means were constrained to be equal across time. This did not lead to a significant overall decrease in model fit ($\Delta\chi^2 = 8.83$, $\Delta df = 4$, $p > .05$; RDR = .071; RMSEA = .049). However, when examining each mean individually, a small but significant decrease for Intellectual Curiosity and an increase for Problem Solving emerged. The change scores indicate, that, on average, individuals engage significantly more in Problem Solving but significantly less in Intellectual Curiosity. The non-significant changes in Reading and Abstract Thinking indicate that on group level, both subfactors remain stable across five years. When latent change means were freely estimated, values

were .108 (Standard Error (*SE*): .055; $p < .05$) for Problem Solving and -.155 (*SE*: .075; $p < .05$) for Intellectual Curiosity. The changes in Reading -.002 (*SE*: .044) and in Abstract Thinking -.028 (*SE*: .058) were not significant.

To analyze change of divergence that is the extent to which the sample homogeneity changes, variances were constrained to be equal across time. This did not lead to a significant decrease in model fit either ($\Delta\chi^2 = 4.45$, $\Delta df = 4$, $p > .05$; RDR = .021; RMSEA = .049), indicating that the amount of interindividual differences remained stable. Stability of divergence implies that across five years overall differences between individuals do not become larger.

In a last step, general versus specific changes were investigated. This aimed at examining whether change in Typical Intellectual Engagement could be subscribed to one underlying mechanisms or if the subfactors change rather independently. First, correlations between the change factors were estimated. Results are shown in Table 7. Positive correlations indicate that change in one factor goes along with change in the other factor. The actual direction of change is indicated by the means. For two of the four factors non significant mean changes emerged, hence, the direction cannot be reliably inferred for Abstract Thinking and Reading. The positive change correlation ($r = .48$) between Intellectual Curiosity and Problem Solving shows that change above average in one factor is accompanied by change above average in the other factor. This means that individuals, who increase in Problem Solving, are less likely to decrease in Intellectual Curiosity. Overall, medium to large change correlations emerged, with the correlation between Abstract Thinking and Reading being the weakest ($r = .31$) and with Problem Solving being the strongest ($r = .73$). Hence, the amount of shared variance ranged from 9% between changes in Reading and Abstract Thinking up to 50% between changes in Abstract Thinking and Problem Solving. The results indicate that although changes in all factors were significantly

related, a substantial amount of variance in change for each factor remains independent from changes in the other factors. Note that fitting a model with a general change factor did not exhibit an acceptable fit. This underlines that different mechanisms underlie the changes in the Typical Intellectual Engagement-factors. Although Typical Intellectual Engagement is one coherent construct, change in the subfactors is, to a substantial amount, driven by different mechanisms. Correlations between level and change are also shown in Table 7. Negative correlations here indicate that higher levels of Typical Intellectual Engagement at T1 are associated with less change. As the largest effect, a medium negative correlation emerged between the level of Abstract Thinking and the change in Problem Solving (r = -.35) and vice versa (r = -.33). No significant relationships emerged between the level factor of Reading and the change factors of the other factors. All other interfactor level-change correlations did not exhibit a systematic pattern and were either small or non-significant (Table 7). Finally, correlations between level and change within a factor were estimated. Negative relationships in the medium to large range emerged (see Table 7). This indicates that, overall, higher levels of the respective factor at T1, were associated with less change. That is, the higher on Typical Intellectual Engagement an individual rated herself, the smaller the change in Typical Intellectual Engagement for this person. We also tested age and gender as covariates to examine whether they accounted for unexplained variance. However, the covariates did not explain additional variance.

Table 7. *Level and change correlations*

	Reading	Abstract Thinking	Problem Solving	Intellectual Curiosity	(5)	(6)	(7)
(5)D_Reading	***-.34****	-.23*	-.24*	-.24*			
(6)D_Abstract Thinking	-.19	***-.50****	-.33*	-.22	.31*		
(7)D_Problem Solving	-.06	-.35*	***-.35****	-.16	.44*	.73*	
(8)D_Intellectual Curiosity	-.22	-.18	-.19.	***-.36****	.50*	.65*	.48*

Note: "D_" indicates the change parameter; Correlations in bold indicate level and change correlation within a factor; Correlations in the right indicate correlations between the change factors: general vs specific change; all other correlations indicate correlations between level and change parameter between different factors; * indicates correlations significantly different from zero on $p<.05$.

2.2.4. Discussion

In the present study we, first, examined the factorial structure of the Typical Intellectual Engagement scale by testing configural, weak, and strong measurement invariance (Meredith & Horn, 2001) and, second, we analyzed the change of Typical Intellectual Engagement across five years.

Strong measurement invariance was found to hold as well as structural stability across five years. Hence, the findings can serve as a replication of the structure of the Typical Intellectual Engagement questionnaire (Dellenbach & Zimprich, 2008). Finding measurement invariance as well as structural stability underlines that Typical Intellectual Engagement as a construct can be reliably measured across time.

We then addressed differential stability. Profound differential change emerged for all the Typical Intellectual Engagement factors, that is, Reading, Abstract Thinking, Problem Solving, and Intellectual Curiosity. Because stability was modelled on the latent level it is, less affected by measurement error. Correlations less than one suggest that individuals change differently. Allemand, Zimprich and Martin (2008) found $r = .69$ for Openness to Experience across 12 years. Hence, the tendency of less than perfect differential stability is known from the literature on personality development. Note that the higher correlations in

Typical Intellectual Engagement still fit into the literature as the study cited above covers 12 years whereas Typical Intellectual Engagement was measured across a 5-year period. Generally, research on critical life events, where nonnormative events impact some individuals, has shown to lead to different developmental trajectories (e.g., Roberts, Helson & Klohnen, 2002). Hence, it might be that changes in rank-order can be partly explained by individual changes in the living conditions. A limitation of the present study is that life events were not included into the analyses. Even within the boundaries that are provided by biological constraints in personality development, motivational influences are possible as well. Research on motivational selectivity (e.g., Riediger & Freund, 2006) has shown that individuals tend to restrict oneself to few personal goals that are regarded as highly important for life satisfaction. In the course of cognitive resources becoming more restricted, differences between individuals concerning the importance of intellectual activity become more pronounced. One individual might enjoy engaging in intellectual activities but still value social interaction higher when she is forced to decide in the presence of declining resources. Hence, we conclude that profound changes in rank-order could reflect motivational selectivity and focusing on different priority goals.

Parameters that describe a construct on the group-level are means and variances. In the present study, small significant mean-level changes only emerged for Intellectual Curiosity and Problem Solving. No changes in variances emerged. We propose the following explanation for the results of the present study. Participating in a longitudinal study on cognitive aging might have a unique effect on interests and intellectual activities itself. Not only are people who are highly interested in cognitive activity more likely to participate in psychological studies (e.g., Cooney, Schaie & Willis, 1988); participating in a study that assesses age-dependent developmental changes in intellectual activities and interests, could itself influence the development. Hence, the slight increase in Problem Solving could reflect

peculiarities of the study. In ZULU, different kinds of cognitive tests are administered. Tests such as the digit symbol test, number series or the standard progressive matrices could have roused the participants' interest to solve for example Sudoku's in their free time. This could have resulted in a perceived increase in Problem Solving across the time period of five years. The decrease in Intellectual Curiosity is in line with research on Openness to Experience (Roberts et al., 2006; Small et al., 2003). Although Intellectual Curiosity in Typical Intellectual Engagement has been found to be higher in old age (see Mascherek & Zimprich, in press), it is possible the increase found in the cross-sectional study may reflect a cohort effect. Also, Intellectual Curiosity was assessed comparatively unspecific. Hence, individuals might rate their global interest in engaging in new topics as decreased. Attending a talk on a new topic outside the home could be complicated by physical deficiencies. This self evaluation could then be confounded by perceived health issues.

We have two explanations for the stability of divergence. First, it seems possible that for significant changes in variances to occur, five years were too short. This explanation is in line with recent research on personality development. Small et al. (2003) found stability of divergence across six years. Hence, the 5-year interval in the present study might have been too short to exhibit changes in variances. Another explanation aims at sample selectivity. All participants were highly educated (see Zimprich et al., 2008) ending up in a comparatively homogeneous group with respect to intellectual interests and activities, which may lead to rather homogeneous developmental trajectories across a five year interval. This idea is supported by the significant negative level-change correlations that emerged for the factors, indicating that individuals scoring high on Typical Intellectual Engagement at T1 experience the least change across a five year period. With most of the participants being intellectually engaged, one may conclude that this imposed a restriction on the level variance in the first

place, and, in combination with the negative level-change correlations led to a non-significant development of variances across five years in the Typical Intellectual Engagement factors.

In a last step we analyzed change correlations between the four subfactors. The highest change correlation emerged between Problem Solving and Abstract Thinking. Both factors describe more abstract aspects of intellectual engagement, which may help explain a large amount of coupled development. Among all change correlations, change in Reading was the change least correlated with all other three factors. The factor Reading aims at a highly trained, overlearned, specific activity that is conceptually different from Abstract Thinking, Problem Solving, and Intellectual Curiosity. Because the Typical Intellectual Engagement questionnaire does not assess what kind of books a person reads, reading does not necessarily imply much cognitive activity besides the activity itself. Hence, even if intellectual engagement decreases, reading as highly trained activity could remain unaffected. Likewise, if the frequency of reading decreases, the general interest in intellectual activity may remain unaffected. The positive change correlation between Problem Solving and Intellectual Curiosity implies that the increase in Problem Solving provides protection against decline in Intellectual Curiosity. Individuals who manage to maintain their level of Problem Solving also benefit from less decrease in Intellectual Curiosity. Because correlations do not imply causality, it is also possible to interpret the results the other way around: Individuals who manage to remain intellectually curious could also benefit in a way that Problem Solving even increases in older age.

To summarize, what do the results of the present study tell us about Typical Intellectual Engagement in old age? First, the structure of Typical Intellectual Engagement as a construct remained stable across five years. Second, differential but no mean-level change emerged for all subfactors of Typical Intellectual Engagement across five years. This demonstrates that in order to understand the development of a given construct, it is necessary

to investigate different aspects of development because individual differences may be masked by change or stability on the group level. Third, the change correlations between the four subfactors vary in magnitude, indicating different underlying mechanisms that drive change in Typical Intellectual Engagement. While the present study added important information to the literature on Typical Intellectual Engagement concerning its development in older age, open questions remain to be addressed in future research. The relation between Typical Intellectual Engagement and cognition needs to be further examined. Also, the question of a causal relationship between the constructs remains unanswered. This question could be addressed only longitudinally, including more than two measurement occasions to enable cross-lagged latent analyses. Another yet equally important aspect would concern the development of Typical Intellectual Engagement in middle adulthood, or, generally, across the lifespan. Also, the specific mechanisms that cause interindividual changes in Typical Intellectual Engagement need to be the objective of future studies. Because Typical Intellectual Engagement is conceptualized as influencing typical intellectual performance, another area of research could engage in the question if Typical Intellectual Engagement could be trained in different settings or different stages across the lifespan.

3. SUBJECTIVE AND OBJECTIVE MEMORY PERFORMANCE

In chapter 3, the relation between subjective memory self-evaluations and objective memory performance is further investigated from two different angles. While in *Study 3*, the relation between subjective and objective memory performance is addressed in a group of clinical outpatients; in *Study 4* the question of the relation between the two constructs is approached from a methodological point of view.

3.1. What do cognitive complaints in a sample of memory clinic outpatients reflect?[3]

3.1.1. Introduction

In cognitive aging, subjective cognitive or memory complaints, that is, negative judgments about one's cognitive performance, are important as a criterion for diagnosing mild cognitive impairment (MCI; Dilling, Mombour, Schmidt, 2000; Petersen et al, 1999). However, research on the relation between subjective cognitive or memory performance ratings and objective cognitive or memory performance as measured by standardized instruments has repeatedly found only small to moderate relations between both constructs (cf., Cavanaugh & Poon, 1989; McDonald-Miszczak et al., 1995). Notably, the relation between subjective and objective performance has mainly been studied in healthy samples (Jorm et al., 2001; Valentijn et al., 2006). There is a body of research, though, on the predictive value of subjective cognitive complaints in clinical samples, which has led to controversial results (Geerlings, Jonker, Bouter, Adèr & Schmand, 1999; Kliegel, Zimprich & Eschen, 2005; Levy-Cushman & Abeles, 1998; Schofield et al., 1997;). While in some studies no relation between cognitive complaints and pathological cognitive decline was found, in others subjective cognitive complaints emerged as a valid predictor for higher risk

[3] A similar version of this chapter has been submitted for publication at "The Journal of Gerontopsychology and Geriatric Psychiatry" (Mascherek & Zimprich)

of developing MCI or dementia even when no signs of objective cognitive impairment were present at time of assessment. Dufouil, Fuhrer and Alpérovitch (2005), for example, reported that even after controlling for depression, drug intake and baseline cognitive performance, cognitive complaints were a valid predictor for developing cognitive impairment. In their comprehensive review, Jonker, Geerlings and Schmand (2000) came to the conclusion that subjective memory complaints could be seen as early signs of beginning dementia. On the contrary, Flicker, Ferris and Reisberg (1993) as well as O'Brien et al. (1992) did not find any reliable relation between clinically relevant memory impairment and subjective cognitive complaints. Given this conflicting evidence for the predictive value of cognitive complaints for the evaluation of clinically relevant cognitive decline, the function of cognitive complaints needs to be further evaluated. Several hypotheses of what subjective cognitive ratings reflect have been put forward.

First, cognitive complaints may not only be determined by actual memory performance, but could also be linked to affect or to stable personality traits such as neuroticism (Kliegel & Zimprich, 2005; Mowla et al., 2007; Wilhelm, Witthöft & Schipolowski, 2010). Neuroticism, which is defined as a tendency to enduring or frequent states of anxiety and nervousness (e.g., John & Gross, 2004), may negatively color self-judgments in general and cognitive performance in particular. In line with this assumption, Pearman and Storandt (2005) found that the facets anxiety and self-consciousness of the personality trait neuroticism explained almost one third of the variance in subjective memory complaints. Cognitive complaints may be an expression of permanent worry or self-monitoring. In a study on the relation between neuroticism and negative physical outcomes, Charles, Gatz, Kato and Pedersen (2008) proposed as the explanatory mechanism that stronger neuroticism could be associated with greater internal self-focus. This could result in a heightened awareness of and a permanent preoccupation with even small negative

deviations from an individual's norm. These deviations are easily perceived as stressful and threatening. A similar explanatory approach could be applied to self-judgments of cognitive functioning. This seems especially true for old age where cognitive functioning and age-related decline are a salient and more or less permanent topic and threat for individuals (Weiss & Lang, in press). As a consequence, cognitive complaints could be interpreted as an expression of neuroticism rather than a reliable monitoring of actual cognitive performance.

Another line of research has investigated the possible influence of affective states on cognitive complaints. Depressive affect, for example, is linked to the tendency to report and recall negative events or thoughts repeatedly (e.g., Hautzinger, 1998). Hence, in judging one's performance, some individuals may draw their attention to episodes of cognitive malperformance rather than carefully monitoring different episodes of cognitive performance and then evaluate one's performance. This could explain why cognitive complaints are reliably related to depressive affect (e.g., Jylhä et al., 2009). Similar to neuroticism, depressive affect may cloud one's evaluation of cognitive performance. To summarize, there is a body of both theory and research which shows that cognitive complaints are affected by personality traits and affective states. Importantly, from this perspective, one could argue that cognitive complaints do not or at best in part reflect realistic inferences about one's cognitive performance, but rather a general way of judging oneself that is affectively colored.

A different line of argumentation has pointed to the fact that although cognitive complaints may not be suitable to assess actual memory performance, a *change* in complaints could serve as an indicator for *change* in cognitive performance (e.g., Martin & Zimprich, 2003; Mascherek & Zimprich, 2011; Zimprich et al., 2003). The reason for this is that, longitudinally, individuals serve as their own controls. Hence, individual differences at cross-section are accounted for, while the variables of interest are individual differences in changes of both cognitive complaints and cognitive performance. As Hertzog and Hultsch (2000)

have discussed, cognitive self evaluations involves monitoring of different aspects of one's own performance. They argued that knowledge of one's own performance comprises the accuracy and the awareness with which different stages of learning and memory are supervised. Studies have repeatedly shown that judgment accuracies vary in dependence of different stages of learning and memory (Rast & Zimprich, 2009). Brown and Middendorf (1996; also, Albert, 1977) showed that in old age, individuals predominantly use temporal comparisons to evaluate their cognitive performance. Inferring from that one could argue that if increasing cognitive complaints are reported from one measurement occasion to the next, this could indicate a reliable change in cognitive performance. This idea is supported by studies that investigated cognitive complaints and cognitive performance longitudinally. Jessen et al. (2010) identified cognitive complaints as a significant predictor of developing dementia in the future. They investigated cognitive complaints in more than 2400 non-demented individuals and found cognitive complaints to predict developing dementia over a time period of 3 years even after controlling for known confounding variables such as depression, education and baseline cognition. Supporting evidence also comes from a study by Jorm et al. (2004) who found that in healthy older men, subjective cognitive complaints were associated with Alzheimer´s disease-related neuropathology in autopsies after death. Hence, cognitive complaints can be seen as indicators for cognitive decline in comparison to earlier performance. This appears especially important for early stages of cognitive decline, because medical treatment that operates on preserving cognitive functioning on a high functioning-level as long as possible could be most effectively if taken early in the progress of decline. In another study, Reisberg, Shulman, Torossian, Leng and Zhu (2010) found in 213 healthy older adults that cognitive complaints indicate a risk of accelerated cognitive decline across 14 years. Hence, cognitive complaints serve as an important indicator for cognitive decline even if objective memory performance remained within normal limits

(MMSE > 29). However, they also found that the magnitude of cognitive complaints decreased with progressing dementia, indicating that cognitive complaints may serve as an indicator of cognitive decline only in very early stages of pathological cognitive changes. This finding fits into the assumption of making temporal comparisons, because in order to make temporal comparisons, previous episodes of performance have to be recalled and the ability to do so is impaired in dementia.

Importantly, it is not only memory or memory changes that are associated with cognitive complaints, but also other cognitive abilities that typically decline in conjunction with pathological processes. In a large population based cohort, Benito-León, Mitchell, Vega and Bermejo-Pareja (2010) found that while cognitive complaints were not related to global memory performance, they were associated with poor verbal fluency. Taken together, the findings referenced imply that both in normal aging and in later stages of dementia, cognitive complaints do not necessarily serve as a valid predictor. But they are an important point of reference for early, subtle onsets of clinical cognitive changes.

The objective of the present study was to investigate whether, while controlling for confounding variables such as depression, age, education and gender, variance in cognitive complaints could be reliably explained by specific cognitive performance tasks as well as different levels of cognitive functioning. A third variable, which is closely related to the question of whether or not cognitive complaints are of value in progressed dementia, was the means of contact. On the one hand, individuals who come by themselves were hypothesized to report higher cognitive complaints yet to show fewer deficits in cognitive performance, that is, are less likely to be diagnosed with MCI or dementia. On the other hand, individuals who were sent by their relatives were hypothesized to report fewer cognitive complaints however are more likely to receive a diagnosis indicating clinical cognitive decline. Research on the importance of informant ratings has shown that in progressed dementia, evaluations

made by informants are of high diagnostic value. MacKinnon et al. (2003) reported that in order to reduce the frequency of false positive or negative ratings in a screening for dementia, informants ratings added significantly to the accuracy of the assessment. Similar results were found by Gonçalves, Arnold, Appadurai and Byrne (2011). They reported that a brief questionnaire for informants on the cognitive functioning level of the patients was as efficient as the MMSE. Hence they concluded that especially in older adults with already progressed dementia, informants' ratings were a valid measure for the clinical status of the patient.

For the analyses of the present study the following hypotheses were formulated: First, we expected that the severity of already present clinical cognitive impairment indicated by diagnosis was negatively associated with cognitive complaints. Also, individuals sent in by their relatives would report fewer cognitive complaints. Second, we expected to find no influence of the global cognitive performance level on cognitive complaints, however, verbal fluency as a specific measure of cognitive functioning was expected to be negatively related, indicating more complaints for those with bad performance in verbal fluency.

3.1.2. Method

Sample

The sample of the present study comprises N = 169 older outpatients from the Erlangen memory clinic at the Institute of Psychogerontology. Mean age of the sample was 76.24 years (SD 7.55 years, 60-89 years), 101 (60%) persons were female.

Selectivity Analyses

The data for the present study stem from 748 outpatients who came to the Erlangen memory clinic at the Institute of Psychogerontology during the period of 2006 to 2010 seeking for an assessment of their cognitive abilities. Of these, 657 (88%) were 60 years of age or older during their visit at the memory clinic. Outpatients with severe psychiatric disorders (e.g., manifest depression) or a history of drug or alcohol addiction were excluded.

Also, persons with a visual or hearing impairment making them unable to complete paper-pencil tests were excluded. Finally, for diagnosis purposes outpatients were required to have complete data records on a standard neuropsychological test battery. In total, there were 477 (73%) persons who fulfilled these criteria. Of these persons, 354 (74%) were administered a questionnaire on subjective cognitive complaints (see below). The group of those who answered the cognitive complaints questionnaire did not differ significantly from the group of those who did not with respect to age (76.2 versus 75.2 years, $t = 1.19$, $p > .20$, Cohen's $d = 0.09$), Mini Mental State Examination (24.3 versus 23.9 points, $t = 0.92$, $p > .30$, Cohen's $d = 0.07$), or Verbal Fluency (6.75 versus 6.72, $t = 0.06$, $p > .90$, Cohen's $d = 0.01$), or the percentage of women (62.1% versus 62.2%, $\chi^2 = 0.01$, $p > .90$). Hence, regarding these variables, the subsample of 354 persons adequately represented the sample of 477 older adults.

Finally, 169 (48%) persons of the 354 older adults who answered the cognitive complaints questionnaire also had complete data for all predictor variables of interest. These 169 persons did not differ from the 185 persons who had missing data in at least one of the predictor variables with respect to age (76.13 versus 75.34 years, $t = 0.25$, $p > .80$, Cohen's $d = 0.02$), Mini Mental State Examination (23.95 versus 24.65 points, $t = 1.21$, $p > .20$, Cohen's $d = 0.13$), or the percentage of women (60% versus 64%, $\chi^2 = 0.31$, $p > .50$). There was, however, a statistically significant difference in Verbal Fluency (6.45 versus 7.08, $t = 1.96$, $p < .05$, Cohen's $d = 0.21$). Note that those with incomplete data, on average, had a better fluency than those with complete data, implying that in terms of Verbal Fluency those with complete data records represent a slightly negative selection, although the effect size was small. Taken together, this analysis suggests that the subsample with complete data on the variables of interest represents a slight negative selection of those persons who, in principle, could have participated in the study.

The 169 outpatients were diagnosed based on general medical, neurological, and neuropsychological examinations by a multidisciplinary team. Using ICD 10 criteria (Dilling et al., 2000), the outpatients were assigned to one of the following groups: Subjective cognitive complainers (SCC, $n = 63$), mild cognitive impairment (MCI, $n = 40$), and persons with dementia (PWD, $n = 66$). Table 8 shows some descriptive statistics of the analyses variables separately for the three diagnosis groups.

Measures

Cognitive Complaints. Cognitive complaints were assessed using 14 items (e.g., "Compared to before, do you have greater difficulties in remembering names?" or "Compared to before, do you have greater difficulties in finding your personal belongings, for example, glasses, keys, or wallet?"). Participants were asked to answer the 14 items in a yes-no-format. The answers to the 14 items were summed up in order to form an indicator of cognitive complaints. Note that a higher score implies more cognitive complaints. Cronbach's alpha of the cognitive complaints indicator was .83.

Demographic variables. Sex was dummy-coded with 0 = male and 1 = female. Age was measured as years since birth. Education was coded ordered-categorical with 0 = no graduation, 1 = elementary school, 2 = secondary school, and 3 = grammar school.

Cognitive Status. Cognitive status was measures using the Mini-Mental-State Examination (MMSE; Folstein, Folstein & McHugh, 1975).

Fluency. Fluency was assessed using the CERAD Subtest "animal naming" (Morris, Mohs, Rogers, Fillenbaum, & Heyman, 1988). Briefly, participants were asked to name as many animals as possible within one minute time. Scored was the number of unique animals named.

Depressive Affect. The presence of depressive affect was diagnosed based on the general medical, neurological, and neuropsychological examination. A multidisciplinary team

assigned the outpatients to one of the following groups: 0 = no signs of depressive affect, 1 = some signs of depressive affect, 2 = depressive mood at least once a day affect, and 3 = pronounced depressive affect (depressive mood most of the day).

Table 8. *Sample Characteristics*

	SCC (n = 63)	MCI (n = 40)	PWD (n = 66)
	M	M	M
Age (in years)	70.74	72.48	73.70
Sex (% female)	59	53	64
Education	2.14	1.69	1.25
MMSE	29.36	28.18	22.21*
Verbal Fluency	9.01	8.77	5.08*
Depression	1.45	1.41	1.11
Referred by Physicist (%)	10	28	22
Referred by Relatives (%)	23	26	66*
Cognitive Complaints	4.77	4.95	3.75*

Note: * indicates mean differences between PWD and SCC and MCI on $p < .05$; SCC = Individuals with subjective cognitive complaints; MCI = Individuals with Mild Cognitive Impairments; PWD = Individuals with dementia; M = means

3.1.3. Results

Table 8 shows the means of the analysis variables separately for the three diagnosis groups (SCC, MCI, PWD). Those diagnosed with dementia (PWD) differed significantly from the other two groups (SCC, MCI) with respect to the MMSE, verbal fluency, the proportion of those referred to the memory clinic by relatives, and the number of cognitive complaints. First, the PWD group had a much lower average MMSE score, which demonstrates the amount of cognitive impairment in those diagnosed with dementia. About 41% of variance in the MMSE score was accounted for by diagnosis group alone. Similarly, the average verbal fluency was lower in the PWD group than in the other two groups (SCC,

MCI), implying that those diagnosed with dementia had much more difficulties to retrieve animal names from memory. In verbal fluency, the amount of explained variance by diagnosis groups was about 40%. Also, the average number of cognitive complaints, the dependent variable, was lower in the PWD group than in the SCC and MCI groups. Thus, it appears as if those diagnosed with dementia are no longer aware of their cognitive problems. About 4% of variance were explained in the number of cognitive complaints by diagnosis group. Finally, in the PWD group, much more persons were referred to the memory clinic by their relatives than in the other two groups. This may also indicate those diagnosed with dementia are not fully aware of their cognitive impairment. In terms of effect size (Cohen's w = 0.43), this effect was in the medium to large range.

Regression Analyses

In a first model (Model I), only demographic variables were included as predictors. As Table 9 shows, only the effect of education became statistically significant, implying that persons with a stronger educational background, on average, reported less cognitive complaints. By contrast, cognitive complaints were not significantly related to age or sex. That is, in memory clinic outpatients educational differences can account for cognitive complaints, but effect size was small.

In a second model (Model II), Model I was complemented by cognitive variables (MMSE, verbal fluency) and depressive affect. As can be seen from Table 9, there were statistically significant effects of verbal fluency and depressive affect. Those with higher verbal fluency reported less cognitive complaints, while those with a more pronounced depressive affect, on average, showed more complaints. At the same time, the effect of education decreased slightly compared to Model I, implying that part of the education effect was captured by depression and fluency. Note that the MMSE did not reach statistical significance. One reason for this is that, compared to the MMSE, the verbal fluency measure

appeared to tap those aspects of cognitive functioning that are most relevant in forming cognitive complaints. After including the three predictors, the amount of explained variance increased. Note that opposed to many previous studies, there was an effect of cognition (verbal fluency) on cognitive complaints, implying that cognitive complaints do, at least in part, reflect actual cognitive performance.

Table 9. *Results of Regression Analyses*

	Model			
Predictor	I	II	III	IV
Sex	-0.61	-0.29	-0.49	-0.39
Age	-0.02	-0.04	-0.01	-0.01
Education	-0.79*	-0.54*	-0.72*	-0.74*
MMSE		-0.10	-0.02	-0.03
Fluency		-0.27*	-0.34*	-0.03
Depression		-1.18*	-0.89*	-0.95*
MCI			-0.03	-0.05
Dementia			-2.06*	-2.03*
Referred by Physicist			-0.10	-0.16
Referred by Relatives			-1.31*	-1.23*
MCI x Fluency				-0.40*
Dementia x Fluency				-0.43*
R^2	**0.03**	**0.08**	**0.16**	**0.18**

Note: * $p < .05$; MMSE = Mini Mental State Examination; MCI = Mild Cognitive Impairment

Subsequently, in Model III, two dummy variables reflecting an MCI diagnosis (0 = no, 1 = yes) and a dementia diagnosis (0 = no, 1 = yes) were included. In addition, the type of referral was added to the model in form of two dummy variables (see Table 9). Of these new predictor variables, the diagnosis of dementia had a statistically significant effect in the reverse direction: those with a dementia diagnosis reported, on average, two complaints less than persons with other diagnoses. This findings either imply that those with dementia are not

or no longer aware of their cognitive impairment. Also, a significant effect emerged for those referred to the memory clinic by their relatives. These persons, on average, reported about 1.3 complaints less. Similar to those with dementia diagnosis, those person sent to the memory clinic by their relatives were not fully aware of their cognitive problems. After including diagnosis and type of referral, the effect of depression decreased somewhat. By contrast, the effects of verbal fluency and education became stronger, implying that after controlling for diagnosis and type of referral, the impact of verbal fluency and education was even more pronounced. In total, 16% of variance were accounted for in cognitive complaints.

In a final model (Model IV), an interaction term was included. Specifically, the interaction between verbal fluency and diagnosis was added to the model. Because diagnosis was coded into two dummy variables, two interaction variables were specified. As Table 9 shows, both interactions became statistically significant. How can this finding be interpreted? The findings must be seen in relation to the effect of verbal fluency alone, which was reduced to non-significance. Hence, in persons classified as subjective cognitive complainers (SCC), there is no association between verbal fluency and cognitive complaints. By contrast, in both the MCI and the PWD groups, there is a negative association between verbal fluency and subjective complaints, implying that those with higher verbal fluency report less cognitive complaints. The other effects remained virtually unchanged. Overall, model IV explained 18% of variance in cognitive complaints.

3.1.4. Discussion

In the present study we examined whether cognitive complaints are associated with cognitive performance in a group of memory clinic outpatients differentially diagnosed as persons with subjective cognitive complaints (SCC) only, persons with mild cognitive impairment (MCI), and persons with dementia (PWD). Concerning sample selectivity, the subsample of 169 persons with complete data records represented a somewhat negative

selection with respect to verbal fluency. Because this subsample did not differ with respect to all other variables, we assume that the large dropout is a result of the assessment conditions found in practice in a memory clinic. Patients were primarily assessed in preparation for possible clinical treatment. Hence, mental status of patients had priority, which only if considered necessary resulted in administering all tests in an individual – without being highly systematic. Notwithstanding, one has to keep in mind that attrition diminishes the generalizability of the results of our study.

A number of mean comparisons showed that the PWD group had a significantly lower MMSE score, showed less verbal fluency, and reported less cognitive complaints. Also, a higher proportion of persons with PWD was referred to the memory clinic by their relatives. These analyses showed that persons diagnosed with dementia are not fully aware of their cognitive impairment and, hence, do not see the necessity to visit a memory clinic based on their own initiative. Rather, to a large part they are advised by their relatives to seek help in a memory clinic.

Subsequently, regression analyses were conducted. In line with recent findings, no significant effects of age and sex on cognitive complaints emerged (e.g., Slavin et al., 2010). Concerning education, we found that less educated individuals reported more cognitive complaints. In the literature, generally controversial findings exist with respect to the effect of education (Jonker et al, 2000; Slavin et al, 2010). In many community-based studies, low levels of education have been found to be associated with more cognitive complaints (Schofield et al., 1997). Ramakers et al. (2009), in contrary, found higher levels of education to be associated with more complaints in a sample of individuals seeking help for subjective memory complaints. Elsewhere (Kliegel & Zimprich, 2005), we have demonstrated that the assumption of one homogenous sample with regard to cognitive complaints may not be tenable. That is, there may be a group of persons where less education is related to more

complaints. At the same time, in a subgroup of people, higher education may elicit more cognitive complaints, because these persons may be more afraid of losing their cognitive abilities.

Depressive affect was included as an additional control variable. As expected, depression had a positive effect on the number of cognitive complaints, indicating that higher levels of depressive affect are associated with more complaints. Note, that individuals that were clinically depressed were excluded from the analyses. Still, the effect of depressive affect was also present in subclinical ranges. It is known from the literature that depression influences the report of cognitive complaints (e.g., Mowla et al., 2007; Zimprich et al., 2003). Our findings provide additional evidence that the current emotional state is an influential variable when asked to judge one's cognitive performance. Theoretically, this relation seems plausible. One central characteristic of depressive affect is rumination combined with high levels of self-consciousness. This may increase the tendency to focus on negative rather than on positive aspects (Hautzinger, 1998). Hence, depressed individuals may, for example, be liable to over-interpret a transient state of forgetfulness as a permanent cognitive impairment and may, worried as they are, also be more likely to report it.

The diagnosis of dementia had the strongest effect on cognitive complaints. While individuals with dementia reported significantly less cognitive complaints, patients with MCI were not significantly different from healthy individuals in terms of the reported complaints. We suggest that the diagnosis of dementia as an influential effect on cognitive complaints mirrors the fact that being diagnosed with dementia implies severe impairment of cognitive functions and awareness. Impaired awareness is common in demented patients as well as the report of fewer complaints (e.g., Stewart, McGeown, Shanks, & Venneri 2010; Reisberg et al., 2010). That is why fewer reported cognitive complaints – despite obvious cognitive problems – could be interpreted as an additional, relevant aspect in the course of diagnosing

dementia. However, it could also be that the PWD group underreported complaints in order to fake "good." Keeping in mind that a large proportion of these persons were referred to the memory clinic by their relatives, it could be that they tried to dissimulate. But this would require an intention to do so, which appears unlikely in demented persons. Concerning the group of individuals diagnosed with MCI, the results of our study suggest that the amount of reported cognitive complaints does not differentiate between healthy or mild cognitively impaired individuals. Although this has also been reported in the literature (Slavin et al., 2010), cognitive complaints are one criterion for diagnosing MCI (Dilling et al., 2000; Petersen et al., 1999).

For demented patients, there appears to be an indirect statement of cognitive impairment that is given by relatives sending them to a memory clinic could. This fact alone could serve as an indicator for cognitive impairment, which could function as a useful hint for clinicians being confronted with individuals who were referred to the clinic by relatives, but who do not report complaints. Because relatives are likely to include earlier levels of functioning into the evaluation, this could be used as an important source of information for clinicians in the course of diagnosing. By contrast, the group that was sent in by a physicist did not differ from the group that came on their own initiative. The reasons why a physicist might send in a patient for an assessment are diverse, however. He or she could, for example, just follow the request of a patient or, alternatively, may base his or her decision on the clinical impression. Hence, the group of individuals referred to the clinic by a physicist was probably too diverse as to exhibit a concurrent pattern of complaints.

Including the MMSE into the analyses did not significantly add information to the analyses. In line with recent literature (Benito-León et al., 2010), we conclude that the MMSE as a screening instrument assesses cognitive functioning too broadly. It is not well suited to detect subtle, beginning cognitive impairments. In other words, when the MMSE

classifies as a useful instrument, cognitive complaints might not be of any relevance for performance evaluation anymore. In contrast to the general MMSE measure, verbal fluency was an influential parameter. A negative relation between verbal fluency and cognitive complaints emerged. This indicated that the better the performance in verbal fluency the fewer cognitive complaints were reported (see also Benito-León et al., 2010). While global cognitive measures are not sensitive enough to detect very early onsets of cognitive decline, executive functions as operationalised in verbal fluency, could serve as an indicator. Considering the relation between cognitive complaints and verbal fluency performance, both measures could serve as valuable sources of information in a screening procedure to assess early onsets of cognitive malfunctioning.

Importantly, however, the relation between verbal fluency and cognitive complaints was different in the different diagnostic groups. While for the SCC group, no significant relation emerged, MCI and PWD groups reported more complaints in the presence of poorer verbal fluency performance. A possible explanation is that SCC persons have such a high level of cognitive functioning that verbal fluency does hardly differentiate between persons with more or less cognitive complaints. This interpretation has two different implications. First, in the SCC group a much more fine-graded assessment of cognitive abilities could lead to a relation between cognition and complaints. Second, it might well be that in the range of normal cognitive functioning, complaints are due to other reasons than cognition, for example, depressive affect or personality (Kliegel & Zimprich, 2005).

By contrast, in the dementia and the MCI group, better verbal fluency performance was related to fewer cognitive complaints. While the overall level of complaints was lower in the PWD group compared to the SSC and MCI groups, verbal fluency differentiated in both the PWD and MCI groups between individuals within those groups. Specifically, although the diagnosis as such does not differentiate between SCC and MCI individuals, within the

MCI group those performing better on the verbal fluency task report fewer complaints. Hence, verbal fluency may have to fall below a certain threshold in order to become relevant for forming cognitive complaints. Note that changes or emerging difficulties in executive functions might be a phenomenon very noticeable in the everyday life of lay persons. Hart and Bean (2011), for example, found that only after falling below a critical threshold in terms of general intellectual abilities, executive functioning was associated with daily living skills.

Taking together, what do the results of the present study reveal about cognitive complaints in a group of outpatients? First, while sex and age had no effect, lower education was associated with more complaints. Depression was found to strongly influence the expression of cognitive complaints. Second, with respect to cognitive measures, global measures had no significant effect. However, verbal fluency as a more specific measure had a significant effect on cognitive complaints, indicating that lower verbal fluency performance was associated with more complaints. This was true, however, only for the groups of MCI and dementia patients. No significant effect emerged for the SCC group.

When interpreting the results of the present study, one has to keep in mind that overall only 18% of variance were explained by the predictors. This means that other important factors that influence the report of cognitive complaints were not included in the present study. Also, the results of the present study are based on cross-sectional data. Hence, no inferences on developmental trajectories can be made. Assumptions to what extent cognitive complaints might foreshadow dementia are not warranted from the data of the present study. As a last point to mention, our study is limited by a lack of exact experimental control. This, however, is a result of what represents a strength of the present data set as well: Because data stem from outpatients of a memory clinic that came seeking for an assessment of their cognitive abilities, our data represent a population that otherwise would not have been very likely to participate in the course of data collection in a scientific context.

3.2. Correlated change in memory complaints and memory performance across 12 years[4]

3.2.1. Introduction

The nature of the relationship between memory complaints and actual memory performance poses an important issue in applied science. Several studies have demonstrated that memory performance decreases with age (e.g., Verhaeghen & Salthouse, 1997; Hess, 2005) whereas memory complaints increase with age (Commissaris, Ponds & Jolles, 1998; Mol, van Boxtel, Willems & Jolles, 2006). However, the relationships found between subjective and objective measures of memory are of moderate size (cf., Cavanaugh & Poon, 1989; Jorm et al., 2001; Valentijn et al., 2006). Several different ideas have been presented to explain this moderate association.

First, subjective judgments on memory performance might not be solely determined by actual memory performance but might also be strongly related to other variables. The extent of complaints has been found to be strongly related to affective state (e.g., depression) (e.g., Mowla et al., 2007). Depression has also been found to be a major influence on self-reports of cognition (e.g., Metternich et al., 2009). Just as high levels in neuroticism have proven to be related to the prevalence of major depression (Jylhä et al., 2009), memory complaints might be influenced by the level of neuroticism in nondepressed aging samples (Mol et al., 2008; Wilhelm et al., 2010). Lane and Zelinski (2003) investigated the relations between memory-functioning questionnaires and various personality variables and found levels of neuroticism to be related to evaluations of the seriousness and frequency of forgetting.

Second, while questionnaires and tests of memory performance are defined and validated by experts in the field, they are answered by lay people. Differences in the

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definitions of constructs intended by the creators and those understood by the participant might lead to different conclusions about memory performance. For example, differences between lay and expert definitions have been found in research on intelligence (Furnham, 2000). Similarly, different perceptions of memory performance might account for the small relationship between subjective and objective memory performance. Related to this argument, current theories in social psychology state that implicit theories that individuals hold about aging and memory influence responses on self-ratings (cf., Hertzog & Hultsch, 2000). Implicit theories are informal constructs held by individuals about specific psychological phenomena. According to Ross (1989), the manner in which individuals construe their own history is greatly influenced by socio-cultural conceptions of aging. In general, young and old adults tend to believe in cognitive decline in old age (Hertzog & Hultsch, 2000; Kite et al., 2005; McDonald-Miszczak et al., 1995). Although rather drawing the attention to short-term evaluation of performance in an upcoming memory test, Rabbitt and Abson (1990; 1991) found the levels of prediction to be associated with levels of self-confidence. Hence, self-reported cognitive decline might be amplified by people being primed to expect cognitive decline in old age.

Third, a point of reference is necessary to judge a person's performance. In a comprehensive review on the use of questionnaires for the assessment of memory performance, Herrmann (1982) pointed out the fact that content and format of ratings differ between questionnaires as well as individuals. Questionnaires might differ in the way that they assess forgetting, remembering or memory change across a time span of days, weeks or occasions. Additionally, individuals differ in what they use as a baseline for their ratings. Concerning cognitive functioning, people can either use social comparisons (e.g., Arnkelsson & Smith, 2000) or temporal comparisons (cf., Albert, 1977). Although temporal comparisons seem to be the most common in old age (e.g., Brown & Middendorf, 1996), this confounding

aspect cannot be controlled for in cross-sectional research designs. Martin and Zimprich (2003; Zimprich et al., 2003) accounted for this problem applying longitudinal data analyses and latent change models. The relationship between the subjective and objective measurements of memory performance was then assessed via the degree of correlation between the changes in memory and complaints. In their study, Zimprich et al. (2003) assessed memory complaints and memory performance in 202 older adults (mean age = 63 years) at two measurement occasions across 4 years. They found a nonsignificant relationship between memory complaints and cognitive performance at the initial measurement occasion. However, they found a correlation of r = -.64 between changes in memory complaints and changes in actual memory performance. Somewhat contradictory evidence comes from a longitudinal study by Taylor, Miller and Tinklenberg (1992). In 30 older adults measured on three occasions over 4 years they found no relationship between subjective and objective memory change. However, this may be due to the small sample size. In a sample of 97 individuals aged between 30 and 81 Lane and Zelinski (2003) found inconsistent relationships between memory performance and different factors of memory functioning questionnaire across 19 years. Again, this might be due to the comparatively small sample size or to the broad age range studied. The concept of correlated change addresses the question of whether there is a commonality in change across variables (Hertzog & Nesselroade, 2003). If points of reference are assumed to be different between persons but to remain stable within a person across time, each person may serve as his own control group. In that case, one can infer that the degree of correlated change represents the relationship between the variables in a way that is more precise and uncontaminated by initial differences. Commonalities in change scores can only be assessed longitudinally (Hofer & Sliwinski, 2001; Nesselroade, 2001; Willett & Sayer, 1994).

This paper addresses the question of whether the relationship between subjective and objective memory performance can be assessed by analyzing the commonality in change between the two constructs.

3.2.2. Method

Sample

The data for the present study come from the Interdisciplinary Study on Adult Development (ILSE; e.g., Allemand, Zimprich, Martin, 2008), an ongoing longitudinal study on the psychological, physical, and social antecedents and consequences of aging in Germany. Of originally 1001 participants from two cohorts (500 individuals born between 1930 and 1932, 501 individuals born between 1950 and 1952), all 500 participants from cohort one were included in the present study. Mean age at first measurement occasion (T1: 1994) was 62.9 years (*SD* = .91 years, 61-65 years) and at third measurement occasion (T3: 2006) was 74.4 years (*SD* = .88 years, 72-76 years) with 47.9% of the sample being female. While there were complete data records of the variables of interest for all 500 participants at T1, only 297 individuals provided full data records at T3.

Measures

Memory and memory complaints were assessed using measures from the ILSE testing battery. Memory was assessed applying three subtests from the Nuremberg Inventory of Old Age (Oswald & Fleischmann, 1995), namely a picture recall task (PR), a delayed picture recall task (DP), and a wordlist recall task (WR). These three items served as indicators for memory.

Memory complaints were assessed using six items from the Nuremberg Self-Assessment List (Oswald & Fleischmann, 1995). The questionnaire measures self-reported problems of different domains in everyday life. Six items depicting memory complaints were selected for the present study: (1) "Lately, I find it difficult to follow the train of thought of

others.“ ,(2) "Lately, I occasionally confuse names, phone numbers or dates.", (3) "Lately, I occasionally forget names and numbers", (4) "Lately, I find it difficult to concentrate on a task.", (5) "Lately, I have more difficulties in planning a journey or other undertakings.", and (6) "Lately, I now and then forget the birth dates of relatives or close acquaintances." Memory complaints items were scored on a four-point Likert scale from 4 = "completely false" to 1 = "completely true". Hence for memory complaints, lower scores indicate stronger memory complaints. The six items served as manifest indicators for memory complaints.

Statistical analyses

To test the extent to which the chosen measures depict the same construct across time or groups, we first test for measurement invariance (MI) (Meredith & Horn, 2001). In practice, MI can be tested by fitting confirmatory factor models that impose different degrees of restrictions to a data set (cf., Lubke et al., 2003; Meredith, 1993; Meredith & Horn, 2001; Meredith & Teresi, 2006). For the basic configural invariance model, items are constrained to load on the same factor across time. For weak factorial invariance, factor loadings are constrained to be equal across time and for strong factorial invariance to hold, item-intercepts are constrained to be equal across time. After measurement invariance is established, we then analyze the commonality in change by correlating the change scores of the two constructs across time using second-order latent growth curve models (e.g., Sayer & Cumsille, 2001).

As criteria for model fit, we report the Comparative Fit Index (CFI), and the Root Mean Square Error of Approximation (RMSEA. Values of the CFI above 0.90 denote a well-fitting model, whereas for the RMSEA values less than 0.08 may be interpreted as acceptable model fit (Hu & Bentler, 1999). In addition, we report adjusted χ^2-values, degrees of freedom (*df*), and corresponding *p*-values for all models examined as well as the Satorra-Bentler scaled χ^2-difference-test for comparing nested models (Satorra & Bentler, 2001). Throughout the analyses we used SPSS 18 and Mplus version 3.0 (Muthén & Muthén, 2004).

Modeling description

We begin analysis of the data with a first-order model for memory and memory complaints across three measurement occasions each. Because data for memory complaints were measured on an ordinal scale, we estimated thresholds between categories (Millsap & Yun-Tein, 2004). The number of thresholds is equal to the number of categories minus 1, resulting in 3 thresholds to be estimated. We used the theta parameterization and WLSM estimator for our analyses (Muthén & Asparouhov, 2002; Muthén & Muthén, 2004). Model parameterization and factor scaling of the configural invariance model were achieved by fixing the factor means to zero. Additional constraints were then imposed to test specific models. To scale the latent variables, factor loadings for Item 1 for memory complaints and the picture recall task were set to 1. For all six first-order factors, the means were set to 0 across the three time points. For the second-order models, one level factor and one slope factor were specified for each of memory and memory complaints. Because time intervals were 4 and 8 years respectively, slope factor loadings were set to 0, 1 and 3, corresponding to linear growth.

3.2.3. Results

Different degrees of measurement invariance (MI) were tested. The configural invariance model achieved an acceptable fit (adjusted χ^2 = 1040.7, df = 302, p < .01, CFI = 0.96, RMSEA = 0.070), indicating that the same manifest indicators underlie the latent constructs across time. Weak MI, that is, constraining the factor loadings to be equal across time, did not change the model fit significantly (adjusted χ^2 = 1029.93, df = 316, p < .01, CFI = 0.96, RMSEA = 0.067; Satorra-Bentler scaled (S-B) $\Delta\chi^2$ = 17.74, Δdf = 14, ns), indicating that the manifest indicators assessed the latent factors in the same way at each time point. Strong MI did not hold (adjusted χ^2 = 1652.57, df = 351, p < .01, CFI = 0.93, RMSEA = 0.085; S-B $\Delta\chi^2$ = 905.01, Δdf = 35, p < .01). We then tested for partial measurement

invariance (Byrne et al., 1989). Inspection revealed that the intercept for memory that caused the largest decrease was for delayed picture recall. The items representing immediate recall could be constrained to be equal across time, indicating that delayed recall behaves differently than immediate recall. For the memory complaints items a comparable picture emerged. Items 2, 3, and 6 could be constrained to be equal across time where Items 1, 4, and 5 could not. The former items target specific episodic memory problems whereas the latter depict rather general difficulties in concentration. Although compared to the weak measurement invariance model, the partial strong measurement invariance model fit the data statistically significantly worse according to the chi-square difference test (S-B $\Delta\chi^2 = 65.25$, $\Delta df = 14$, $p < .01$), we accepted this model for conceptual reasons (discussion below).[5]

Analyses continued using a second-order latent growth curve model. In this model, memory and memory complaints each were provided factors for level and slope across the 12 years. The factor loadings of the second-order level factors were set to 1, their means set to zero, and their variances freely estimated. Covariances between the memory level factor and the complaints level factor as well as between the memory slope factor and the complaints slope factor were freely estimated. According to model fit criteria this model fitted the data of the present study well (adjusted $\chi^2 = 1133$, $df = 343$, $p < .01$, CFI = 0.95, RMSEA = 0.068), hence we accepted it as our final model (see Figure 4). Standardized factor loadings and unique variances can be seen in Table 10.

[5] We also tested strong measurement invariance using continuous item factor analysis and parcels. However, both ways of structuring the data lead to similar results.

Table 10. *Standardized factor loadings of the manifest variables and unique variances*

Manifest indicators	T1	T2	T3
Picture recall	.51	.56	.67
Delayed picture recall	.58	.58	.64
Wordlist recall	.46	.41	.49
Compl 1	.78	.78	.82
Compl 2	.50	.50	.55
Compl 3	.77	.77	.81
Compl 4	.75	.75	.79
Compl 5	.66	.68	.71
Compl 6	.76	.77	.80
Variance memory	.03	.1	.07
Variance complaints	.2	.2	.1

Note: T1 = First measurement occasion (1994), T2 = second measurement occasion (1998), T3 = third measurement occasion (2006); Compl1 - 6: Subjective memory complaints items; Picture recall = unstandardized loading fixed to 1 to scale the latent variable; Compl 1 = unstandardized loading fixed to 1 to scale the latent variable; Factor loadings refer to the final model. Standardized factor loadings can be different in numbers although equality constraints do hold, because of the standardization

The skew of the distribution of memory complaints data did not change substantially over time. Taken together, for all items the general distribution remained the same with the highest weight on the first threshold and decreasing weight on threshold two and three. Variances for the level factors were 1.197 (*SE:* 0.19) for memory complaints and 0.209 (*SE*: 0.036) for memory performance. Variances for the slope factors were 0.066 (SE 0.36) for memory complaints and 0.029 (*SE*: 0.01) for memory performance. Unstandardized means for the slope factors were -.158 ($p < .05$) for memory complaints and -.169 ($p < .05$) for memory performance. According to Byrne et al. (1989) means on latent level are interpretable even without full strong measurement invariance. Note, however, that if constraining intercepts of the memory complaints items that aim at difficulties in concentration, the mean-level change in memory complaints is non-significant anymore (see discussion below).

The covariance between the level factors was 0.116, $p < .05$, whereas the covariance between the slope factors was 0.015, $p < .05$. We also tested the covariance between the slope factors against a zero slope-slope covariance using a LR test (Hertzog, von Oertzen, Ghisletta & Lindenberger, 2008). This led to a significant decrease in model fit (S-B $\Delta \chi^2 = 8.16$, $\Delta df = 1$, $p < .01$). To test whether the covariances between levels and slopes differed significantly, we constrained them to be equal and refitted the model. This also led to a significant decrease in model fit (S-B $\Delta \chi^2 = 6.93$, $\Delta df = 1$, $p < .01$). We conclude that the relationship between the slope factors was significantly different from zero and larger than the relationship between the level factors. In terms of effect-sizes, the relationship between memory and memory complaints at T1, was $r = .23$, $p < .05$. The correlation between the slopes of the two constructs was $r = .39$, $p < .05$. Correlations between the level and slope factors within the constructs were not significant ($r = -.16$, ns for memory complaints and $r = -.03$, ns for memory performance). The correlations remained unaffected by the different degrees of partial measurement invariance.

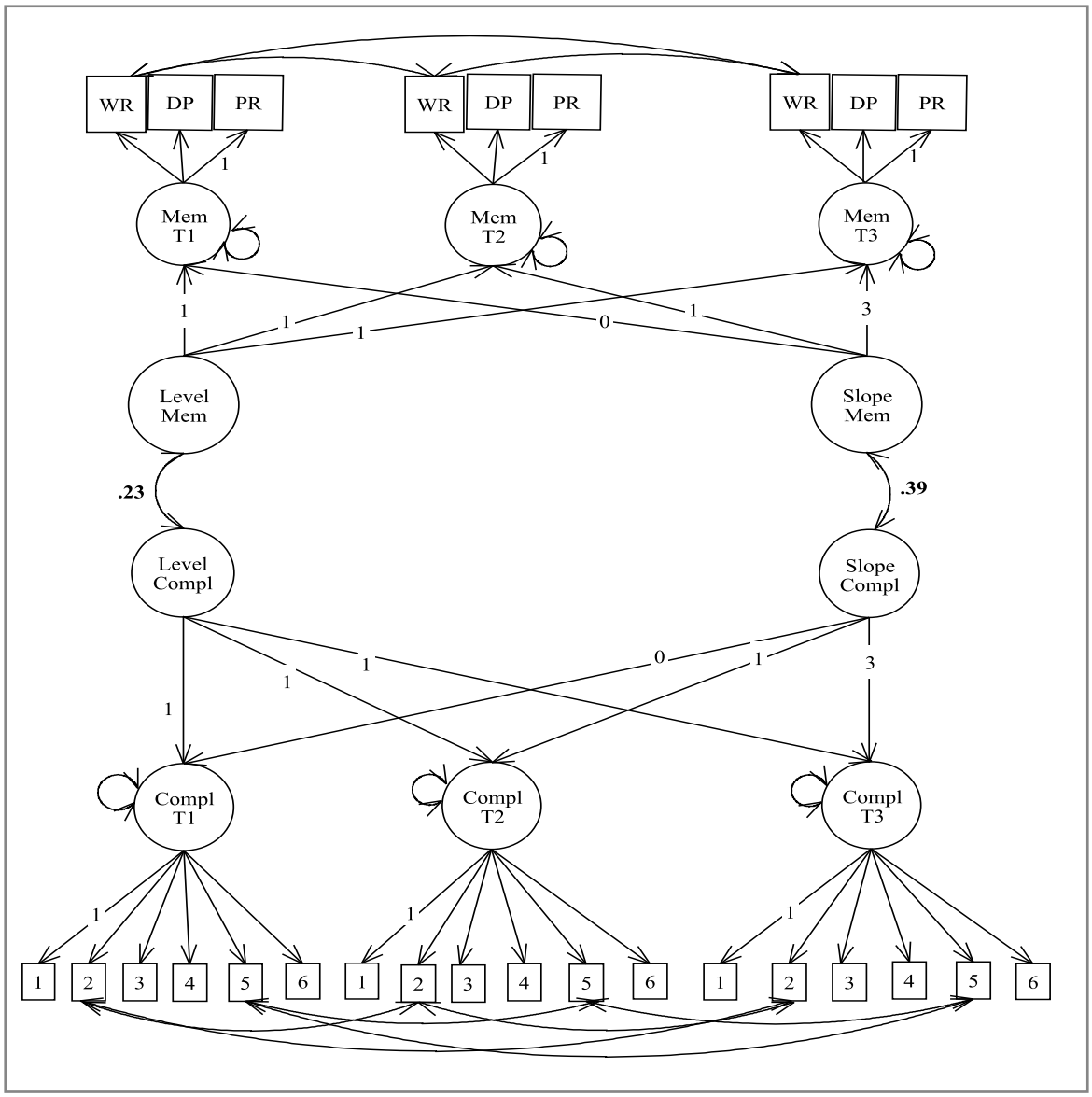

Figure 4. Final second-order latent growth curve model
Note: adjusted χ^2 = 1133, *df* = 343, p < .01, CFI = 0.95, RMSEA = 0.068
WR = Word recall, PR = Picture recall, DP = Delayed picture recall, 1 - 6 = Memory complaints Items 1 to 6, T1 = first measurement occasion, T2 = second measurement occasion, T3 = third measurement occasion, Numbers denote fixed parameters for model specification, Numbers in bold indicate correlations between levels and slopes, Means of complaints and memory first-order factors are set to zero.

3.2.4. Discussion

In the present study we examined whether the relationship between memory complaints and memory performance could be assessed more precisely by analyzing the commonality in change between the two constructs.

First, we examined different degrees of measurement invariance. Strong factorial invariance did not hold. The pattern that emerged for partial strong factorial invariance indicated invariance for those memory items measuring immediate recall but not for those measuring delayed recall. For the memory complaints items, invariance was shown to be tenable for those items measuring memory complaints in specific episodic memory tasks (i.e., remembering names and numbers) but not for the items measuring global memory changes (e.g., difficulties in concentration). The results indicate that changes in immediate recall can be accounted for by the latent memory factor, whereas changes in delayed recall remain partly unexplained by the memory factor. The same is true for the memory complaints items: while changes in the specific episodic memory complaints can be accounted for by the latent factor, changes in the items assessing complaints about more global concentration cannot. We have the following explanation for this: concentration is a less specific measure for memory. It seems plausible that these less-specific aspects of self-assessment are more difficult to evaluate, and therefore more strongly influenced by mediating variables such as affect or stereotypes about age. Just as affect has been shown to influence memory self-evaluation (e.g., Metternich et al., 2009), the different invariance characteristics of the items can be interpreted as representing the specific influence of affective variables on aspects of self-evaluation of memory complaints. A related explanation seems plausible for the memory performance items. From the literature it is known that memory performance is influenced by perceived self-efficacy (e.g., Bandura, 1989). Although these effects are small, it seems plausible that the delayed recall is more prone to affective influences than is the immediate recall. In the deliberate process of recalling information after a delay, it seems reasonable that affective influences are more distinct. However, more detailed future research is needed to provide support for this explanation.

On the latent level we find a decrease in memory performance and an increase in memory complaints. This result is expected from the literature (e.g., Commissaris et al., 1998; Hess, 2005). Note, however, that in the present study the significance of the mean-level changes in memory complaints depended on the choice of items that were constrained to equality across time. Constraining the specific memory complaints items (Item 2, 3, 6) led to significant mean-level changes, whereas constraining the less specific items (Items 1, 4, 5) to be equal led to a non-significant mean-level change. A reasonable interpretation of this result is that items that are possibly influenced more strongly by affective variables could mask the change in mean-level. Hence, differences on intercept level that are not completely mediated by the common factor but are rather confounded with specific additive influences result in the possibility that changes are masked (for extensive discussion see Gregorich, 2006; Meredith & Teresi, 2006).

Analyses then focused on examining correlated change in memory performance and memory complaints. In terms of r^2 we found the relationship to be three times stronger between the slopes than the levels. Although the effect size is only moderate for the change correlation, the results imply that development is dynamic rather than static, and that in order to assess the relationship between the development of two constructs, the dynamic nature of development must be represented methodologically as well. The relationship between memory and memory complaints is therefore described more precisely in the analysis of mutual development than in the analysis of static structure. From a conceptual point of view, the results of the present study indicate that individuals are sensitive to their own memory performance in the way that they notice changes. One limitation of the present study is that the overall correlation between the change parameters is only moderate. This resembles results from previous studies mentioned in the introduction (e.g., Jorm et al., 2001). Two possible explanations seem plausible. First, prior research has suggested that perceived age

differences are ability specific (Lachman & Jelalian, 1984). In the present study, memory performance was assessed using word list and picture memory tasks whereas the items for memory complaints additionally aimed at concentration and everyday performance. Second, although points of reference were assumed to be stable across time; this might not be true for a time span as long as 12 years. It is possible that individuals periodically adjust their reference point and compare themselves to "the person I was a few years ago". Despite these limitations, the significant difference between the level correlation and the slope correlation supports the conclusion that analyzing the commonality in change is highly informative.

What do the results of the present study tell us about the relationship between memory complaints and memory performance? First, across 12 years memory performance decreases while memory complaints increase. Second, items that measure memory performance in a less specific way seem to be more prone to outside influences. Possible mediating variables are affective variables; however, future research is needed to clarify this point. Third, assessing the commonalities in change is more informative than examining static values at a given time point.

4. GENERAL DISCUSSION

Within the overarching framework of how and by which means individuals manage their own cognitive development two specific aspects were addressed in detail in the present thesis: the development of Typical Intellectual Engagement (Goff & Ackerman, 1992) as an individual differences variable that influences the extent of cognitive activities (*Study 1* and *Study 2*) and the relation between objective and subjective memory performance (*Study 3* and *Study 4*). In the following I will summarize and discuss the main findings of the studies and will relate them to the research questions formulated in the introduction. Afterwards, I will integrate the findings of all four studies and will then turn to the discussion of possible future research directions. I will close with drawing some final conclusions.

4.1. Development of Typical Intellectual Engagement across the adult lifespan

The first aim of the present thesis was to investigate the development of Typical Intellectual Engagement across the adult lifespan (Ackerman, 2000; Goff & Ackerman, 1992). This question was addressed in *Study 1* in a cross-sectional research design in order to describe differences in young and old adults. In *Study 2* the question was addressed in a longitudinal study covering a 5-year interval in order to allow for inferences on developmental trajectories and interindividual differences concerning these trajectories. In taking the results of both studies together, a coherent picture emerges about how Typical Intellectual Engagement might develop across the adult lifespan – generally and individually.

Measurement Invariance

As discussed in chapter 1.4., in both studies measurement invariance (MI) was tested. According to Meredith (1993), testing MI is an explicit method of ensuring that characteristics of the instrument applied remain stable across groups or time. In both of our

studies on Typical Intellectual Engagement, strong measurement invariance was established across groups (*Study 1*) and across time (*Study 2*). However, with the restriction that in *Study 1* only partial strong MI was found to hold. This indicates that for the respective items (here TIE1B, 2A, & 3D), intercepts could not be constrained to be equal across groups. Although from a statistical perspective, partial MI does not result in significant inaccuracies of the analyses (e.g., Byrne et al., 1989; Reise et al., 1993), conceptually this indicates that the items in question are comprehended differently across groups. Importantly, those differences cannot be accounted for by differences in the latent construct (here Typical Intellectual Engagement), but must be due to other influences that were not accounted for in *Study 1*. The conclusion that can be drawn for the measurement characteristics of the Typical Intellectual Engagement-scale hence is that although group differences or across time changes can be meaningfully and unambiguously interpreted as changes in the underlying latent construct (cf., Byrne et al., 1989; Lubke, et al., 2003; Rast, Zimprich, van Boxtel & Jolles, 2009), one has to bear in mind that some items of the scale are not as invariant as others. This seems to be especially true for large age differences or for group comparisons. Whether it is the age difference (almost 50 years) or the different groups cannot be disentangled from *Study 1*. Both seem reasonable: either the respective items could mean something rather different to young and old adults or the samples in *Study 1* were, despite the great effort to control for that, systematically different with respect to an uncontrolled variable. Consequently, in future research on Typical Intellectual Engagement and its measurement properties, the items 1B, 2A, and 3D of the present scale should be applied with special attention paid to their invariance characteristics. The analyses of MI revealed that the respective items function differently in both groups with regard to the means.

Change across the lifespan

After discussing the implications of MI for the cross-sectional evidence, I now turn to the discussion of the findings of *Study 1* and *Study 2* concerning the development of Typical Intellectual Engagement across the adult lifespan. According to the different aspects of change mentioned in chapter 1.4., I will successively discuss the findings and will end with a depiction of how Typical Intellectual Engagement can be seen from a lifespan developmental perspective.

Mean level changes

In line with current research on the development of Openness to Experience we, cross-sectionally, found lower levels of Problem Solving, Reading and Abstract Thinking in the old. High stability for Reading and Abstract Thinking emerged longitudinally (e.g., Allemand et al., 2007; Allemand, Zimprich & Martin, 2008; Roberts et al., 2006). A variety of studies on personality (Allemand et al., 2007; Roberts et al., 2006; Small et al., 2003) has found that while personality traits are comparatively stable across the lifespan they still change. Openness, for instance, has been found to decrease in old age (Caprara et al., 2003; Helson et al., 2002; McCrae et al., 1999). This has been interpreted as reflecting proceeding limitations of resources and the tendency to focus on important existing relationships and aspects and maintaining current levels of functionality rather than engaging in new things (Baltes & Carstensen, 1996; Carstensen, Isaacowitz & Charles, 1999; Hess, Germain, Swaim & Osowski, 2009; Hess, Leclerc, Swaim & Weatherbee, 2009). Overall, the findings for Typical Intellectual Engagement as specifically referring to cognitive engagement resemble the trends that are usually found with respect to a general openness to new experiences in personality research. Across a time interval of almost 50 years (*Study 1*), the plasticity of Typical Intellectual Engagement showed in the higher and lower levels of the subfactors of Typical Intellectual Engagement. The stability that was found across 5 years in Reading and

Abstract Thinking underscores the idea of Typical Intellectual Engagement being a rather stable, trait like construct that is not subject to rapid, mood-dependent changes. The results that are not in line with research on Openness to Experience emphasise the eligibility of Typical Intellectual Engagement as an independent construct. It does contribute information that cannot be covered by assessing only Openness to Experience with which Typical Intellectual Engagement is closely connected (e.g., Rocklin, 1994).

However, our studies also exhibited findings that are controversial not only concerning the literature on Openness to Experience, but concerning the results of the two studies itself. While the longitudinal evidence showed that Intellectual Curiosity decreased across 5 years and Problem Solving increased (*Study 2*), higher levels of Intellectual Curiosity and lower levels of Problem Solving in the old in comparison to the young resulted from the cross-sectional study. Hence, depending on time interval covered and methodological approach taken, the results for Intellectual Curiosity and Problem Solving are different between the cross-sectional and the longitudinal study. Besides the possible conceptual implications that will be discussed below, a methodological concern also needs to be addressed to explain the contradictory results of Intellectual Curiosity and Problem Solving in *Study 1* and *Study 2*. It has been discussed in the literature that correct inferences on individual trajectories from the shape of a cross-sectionally derived curve of mean values only is admissible if the entrances from the population are random, the error variances are constant and the developmental trajectories are completely parallel (Hofer & Sliwinski, 2001; Kraemer, Yesavage, Taylor & Kupfer, 2000). Because we know from *Study 2* that at least the assumption of parallel trajectories is violated (as is exhibited in differential change), the reliability of the inferences concerning lifespan development from *Study 1* is limited.

How can the results of Intellectual Curiosity and Problem Solving be interpreted conceptually? Turning to the interpretation of the slight increase in Problem Solving across

five years, this could possibly depict an effect inherent in the conceptualization of the data collection (Zimprich et al., 2008). Because the test battery exclusively consists of cognitive tasks, the engagement in the tasks as such could have led to an increasing interest in and/or a greater salience of Problem Solving. Because some of the tasks were reasoning tasks, it seems possible that solving the tasks in the testing situation could have acted as an "incentive" to engage in crossword puzzle (which is rather knowledge than reasoning) and Sudoku's in the time between the measurement occasions. In a meta-analysis on the effects of cognitive training, Martin, Clare, Altgassen and Zehnder (2011) found that in some studies, cognitive trainings were as effective as being in an active control group with different, non-cognitive activities. From this, one might conclude that being part of a psychological experiment and engaging after that in a "self designed" training (which would resemble being in an active control group) may have an effect on cognitive function. Of course, Typical Intellectual Engagement is not a cognitive ability, still individuals could put on record that they enjoy problem solving more and that they do it more often. This could either be due to an actual increase of engagement in problem solving activities or as an effect of salience. Being more aware of an activity due to the testing situation and the practiced activity after that, might lead to the report of higher levels of Problem Solving (cf., Hess, Waters & Bolstad, 2000).

Turning to Intellectual Curiosity, how can the results of longitudinal decrease and cross-sectional higher levels in the old be interpreted? Results rendered by both studies deserve attention and have conceptual implications. Two possible explanations of the present findings will be given in what follows.

The first, rather methodological interpretation refers to possible sample selection effects. Although all participants attended the tests voluntarily, sample recruitment was different for the young and the old. While the old were recruited in a time consuming

procedure (see Zimprich et al., 2008 for details) via newspaper, senior college courses and records from the central register, the young sample was a convenience sample recruited at a university lecture. Because all individuals were psychology students who received course credit for participation, this could have functioned as an incentive and led to differences in the motivational baseline between young and old adults. It is known from the literature that people who are highly interested in cognitive activities are also more likely to participate in psychological studies (e.g., Cooney et al., 1988). Hence, the higher levels of Intellectual Curiosity in the old as opposed to the young could reflect sample peculiarities rather than real developmental results. The decrease found in Intellectual Curiosity across the five years could then be interpreted as the "real developmental" finding, indicating that, on average, across the lifespan, Intellectual Curiosity decreases and interests become narrower. This is in line with motivational selectivity and cognitive resource selectivity (Hess, 2006; Riediger & Freund, 2006).

Another possible explanation for the controversial results concerning Intellectual Curiosity could be that the developmental trajectory of Intellectual Curiosity is curvilinear with reaching its peak late in adulthood. Typical Intellectual Engagement has been found to be related to crystallized intelligence in young and old adults (Dellenbach & Zimprich, 2008; Wilhelm et al., 2003). It is possible that Intellectual Curiosity as representing a general non-specific interest in new topics, is the "motor behind" lifelong knowledge acquisition. In the course of the necessary allocation of limited resources, the general curiosity in new topics decreases. Investment is centred upon areas that already are of high relevance to an individual (cf., Hess, 2006). This could be represented in the longitudinal decline and still integrates the cross-sectional finding of higher levels in the old as compared to the young. For both explanations references in existing literature can be found (Cooney et al., 1988; Dellenbach & Zimprich, 2008; Martin et al., 2002). However, because to the best of our knowledge no

developmental research on Typical Intellectual Engagement exists, these interpretations remain speculative and need further research to decide which of the interpretations given suit the – then available – additional data best.

Change of divergence

Another parameter that describes differences and changes on the group level and, hence, is well-suited in adding to a general understanding of the development of a construct is change or differences in variances (e.g., Martin & Zimprich, 2005; Zimprich & Mascherek 2010). In the present studies, larger variances in the old as compared to the young emerged for all factors except for Intellectual Curiosity, whereas longitudinally, no changes in variance were found across five years. Assuming that the findings in the cross-sectional *Study 1* represent reliable findings and are no spurious results due to sample specificities, the findings imply that across the lifespan, interindividual difference become larger, however, changes occur rather slow and across a long period of time. Developmental theories suggest that idiosyncrasies become more pronounced and interindividual differences become larger with ongoing time as individuals seek and create environments that suit them best, which in turn reinforces idiosyncrasies (Cattell, 1987; Scarr & McCartney, 1983; Schooler, 1984; Schooler & Mulatu, 2001; Stanovich, 1986). This assumption is mirrored in the greater heterogeneity, that is larger variances, in the old as opposed to the young sample in *Study 1*. The results of *Study 2*, namely stability in variances also fit into literature of personality psychology. While Allemand, Zimprich and Martin (2008) found change of divergence in Openness to Experience across 12 years, Small et al. (2003) found stability of divergence across six years. Hence, the 5-year interval in the present study might have been too short to exhibit reliable changes in variances. Another measurement occasion in the ZULU study in five years could show an increase in variances across the respective time span.

Differential change

A parameter that describes interindividual differences in development is characterized by differential change. Differential change is indicated by a test-retest correlation and can only be assessed longitudinally. It is independent from means or variances (Martin & Zimprich, 2005). Note that perfect test-retest reliability usually is not achieved due to measurement errors. However, because our analyses were conducted on the latent level, measurement errors are accounted for and, hence, any deviation from perfect test-retest correlations, that is r = 1.00, can be interpreted as differential change (Zimprich & Mascherek, 2010). Differential change indicates to which extent the rank-order changes between individuals. That is, differential change describes whether individuals differ in their rate of change. For Typical Intellectual Engagement, significant deviations from r = 1 emerged, indicating interindividual differences in the amount of change (correlations were: r = .84 for Abstract Thinking, r = .83 for Problem Solving, r = .88 for Reading, and r = .81 for Intellectual Curiosity). This leads to the conclusion that across five years, different developmental trajectories emerged for different individuals with respect to the amount and/or direction of change. Interindividual differences in the amount of change require an interpretation that includes idiosyncrasies. It has been argued that continuous small change reflects the adaptation to normative developmental tasks or changes in the environment in order to maintain well-being (e.g., Staudinger & Kunzmann, 2005). Larger individual changes, in turn, might reflect nonnormative changes in the direct context of an individual and its attempts to cope with and adapt to it (e.g., Baltes et al., 1999; Roberts et al., 2002). Possible nonnormative events might have been physical (i.e., health impairments), social or mental, but are specific in time of manifestation and specific to the extent to which they happen to the individual. Although overall, only healthy adults participated in the study, changes that severely affect the self reported extent of Intellectual Engagement could have

happened (e.g., the birth of a grandchild might shift attention and interests away). Martin, Long and Poon (2002) found lower stability of personality in centenarians across 18 months than in sexa- or octogenarians across five years. This could indicate that in the presence of more and more diminished resources personality traits become more prone to change again. The lower stability might indicate higher levels of vulnerability in the presence of diminished resources. Hence Typical Intellectual Engagement seems to be a construct that, although on the group level rather stable over five years, is prone to significant change within individuals. However, this is presumably rather due to individual, nonnormative influences and resource allocations and does not mirror the normative developmental trajectory.

Structural change

Structural change refers to the question of the strength of the relation between factors across time or groups (Zimprich & Martin, 2010; Martin & Zimprich, 2005). Although this is a question that rather addresses the configuration than the function of a construct, it is still a question worth asking above and beyond concerning measurement properties (see MI discussed above). In cognitive research, this question is subsumed under the question of differentiation and dedifferentiation (e.g., Ghisletta & deRibaupierre, 2005; Ghisletta & Lindenberger, 2003; Zimprich & Martin, 2010). It describes whether, with increasing age, different aspects of a construct become more strongly related. In research on personality, this question has also been addressed with mainly finding structural stability both, at cross-section and longitudinally (Allemand et al., 2007; Caspi & Roberts, 2001; Srivastava, John, Gosling & Potter, 2003; but Allemand, Zimprich & Martin, 2008). Hence, the structural stability that was found in Typical Intellectual Engagement longitudinally fits into present research on personality. However, the cross-sectional finding of *Study 1* showed higher interfactor correlations in the old, implying dedifferentiation (Zimprich & Martin, 2010). In old age, the

correlations between the different facets of Typical Intellectual Engagement were stronger than they were in young age.

All older study participants were already retired. One might argue that this leads to an organisation of daily living that is mainly unaffected by institutional restraints which exert influence on an individual in workplace and educational institutions. Interests and abilities may not necessarily be allocated to specific and differential tasks and environments. Rather, an individual may focus on environments that suit her best. This selected environment reciprocally effects the development and display of individual characteristics (Gestsdottir et al., 2009; Lerner, 1982; Schooler, 1984). Also, increasing correlations between the subfactors could represent the deliberate alignment of resources on fewer, highly prioritized goals (see Riediger & Freund, 2006). The concentration of decreasing resources on a few meaningful goals and activities, hence, could result in resources becoming itself more homogeneous as would be reflected in higher correlations between factors.

Specific versus general change

To fully analyze a multifactorial construct from a developmental perspective, the question of whether the factors change together or independently also needs to be addressed. Again, this can only be assessed longitudinally (Martin & Zimprich, 2005). For Typical Intellectual Engagement, change factors shared between 9% and 50 % of variance. This indicates, firstly, that for different factors the commonality in change was differentially strong and, secondly, that even for factors sharing the most variance (Abstract Thinking & Problem Solving), half of the change in each factor occurred independently from change in the other factor. An interesting aspect of the change correlations compared to the level correlations is that the change correlations in some factors were higher than the static correlations at baseline (*Study 2*). This finding might be interpreted as hinting at dedifferentiation that was already found in *Study 1* across almost 50 years. Although

structural stability was found in Typical Intellectual Engagement across five years, the fact that the change correlations were in part even higher than the factor correlations at baseline could, over long time spans, lead to a convergence of the factors. Here, again as found in research on personality (e.g., Allemand et al., 2007), changes that do occur might only occur slowly across a longer period of time.

After all, what do *Study 1* and *Study 2* exhibit concerning the development of Typical Intellectual Engagement across the adult lifespan? On the one hand, results underscore the conceptualization of Typical Intellectual Engagement as a trait-like construct (Goff & Ackerman, 1992). In line with research on other aspects of personality (Caspi & Roberts, 2001), changes in Typical Intellectual Engagement do occur across the adult lifespan, however, rather slowly. On the other hand, Typical Intellectual Engagement also seems to fit into research on motivation as increases in some factors have been found, maybe reflecting a deliberate selection of goals that are related to intellectual engagement and highly focused invested effort to attain these goals (Riediger & Freund, 2006). The interindividual differences in intraindividual change indicate that the development of Typical Intellectual Engagement is influenced by unique, nonnormative influences. Finally, *Studies 1* and *2* underscore the "raison d'être" of Typical Intellectual Engagement as an independent construct, because the multidimensionality and multidirectionality (Baltes, 1987) of this individual differences variable has not been captured in other related constructs such as Openness to Experience.

Future implications

The strongest call that can be made in terms of specific future research on Typical Intellectual Engagement is connecting developmental trajectories of Typical Intellectual Engagement with cognitive variables. This has been done in young adults where Typical Intellectual Engagement has been mainly tested as a potential predictor for academic

achievement (Furnham, et al., 2008; Furnham & Chamorro-Premuzic, 2006; Wilhelm et al., 2003). Only few studies have investigated Typical Intellectual Engagement in old age. Namely, the relation between Typical Intellectual Engagement and intelligence and between Typical Intellectual Engagement and Openness to Experience, respectively, were investigated in cross-section (Dellenbach & Zimprich, 2008; Zimprich et al., 2009). However, to the best of our knowledge, developmental studies on mutual development of both constructs have not been conducted. Also, future research should expand the scope of longitudinal data on more than five years. The longer the time interval that can be studied longitudinally, the stronger the inferences that can be made concerning the development of Typical Intellectual Engagement across the lifespan.

Another line of future research on Typical Intellectual Engagement could focus on the relation to motivation. Goff and Ackerman (1992; Ackerman et al., 1995) conceptualized Typical Intellectual Engagement at the intersection of personality and motivation. While specific hypothesis have been formulated for the relation between Typical Intellectual Engagement and knowledge, this has not been done concerning the development of Typical Intellectual Engagement. Hence, in order to fully understand the concept of Typical Intellectual Engagement and in order to make specific predictions about how Typical Intellectual Engagement might contribute to successful ageing and the maintenance of high levels of cognitive functioning, the stable, dispositional aspects of Typical Intellectual Engagement that should presumably be less changeable and the more motivational aspects of Typical Intellectual Engagement that should presumably respond well to deliberate alteration even over a rather short period of time need to be disentangled. Although the results of *Study 1* and *Study 2* suggest that, overall, Typical Intellectual Engagement is not a construct prone to rapid change, this are results from individuals who made no previous attempts to deliberately alter Typical Intellectual Engagement. Hence, one might argue, that normatively,

Typical Intellectual Engagement might not be subject to rapid changes. However, the interindividual differences that were also found in *Study 2* give rise to the question whether nonnormative, specific events and individual intentions could specifically change Typical Intellectual Engagement.

Hence, a more applied line of research on Typical Intellectual Engagement could focus on intervention studies. In intervention studies the quest for disentangling motivational and personality aspects could be addressed as well as the question whether and how Typical Intellectual Engagement could be changed intentionally. As Typical Intellectual Engagement entails a motivational component (Ackerman et al., 1995; Goff & Ackermann, 1992; Kanfer, 1990), we would hypothesize that, within dispositional boundaries, Typical Intellectual Engagement should be susceptible to interventions that seek to change Typical Intellectual Engagement. It is known from the literature that the successful investment of motivational resources is related to a salient goal that is perceived as important (e.g., Kruglanski et al., 2002). Unimpaired cognitive functioning is of great value to individuals (cf., Lawton et al., 1999). Emphasising that individuals can - within certain boundaries - influence their own cognitive functioning should act as an important goal. The stronger Typical Intellectual Engagement is anchored in personality the less it would be changeable in such an intervention. If Typical Intellectual Engagement would be changeable in interventions, this would give evidence to Typical Intellectual Engagement being stronger anchored in motivation and interests. The habit of "intellectual engagement" on a regular basis would then eventually show as a trait-like characteristic of an individual, however, its conceptual origins would lie stronger in motivation than in personality. It is also possible to hypothesise that increasing the motivation of engaging in intellectual activities could be an outcome of an intervention study without concerning levels of Typical Intellectual Engagement in a post-intervention assessment. This is another possible scenario which would hint at Typical

Intellectual Engagement being a stable, motivation-independent aspect of personality that is unaffected by a temporary concentration on and a focused investment of motivational resources in intellectual activity. This conundrum, however, cannot be solved by mere theoretical considerations or correlations of Typical Intellectual Engagement with other constructs. The questions posed call for practical, applied intervention studies and long-term longitudinal assessment to explicitly test those hypotheses.

4.2. What do subjective cognitive ratings reflect in relation to objective cognitive performance?

In *Studies 3* and *4*, the question of what subjective self-evaluations of cognitive functioning reflect with respect to objectively measured cognitive performance was examined. While in *Study 3* the question of what subjective cognitive complaints reflect was addressed in different groups of memory clinic outpatients, in *Study 4* this question was approached from a more methodological perspective, suggesting that maybe the most informative way to look at the relation would lie in examining the commonalities in change rather than assessing the relation at a static time point. In what follows, I shall discuss what both studies reveal about self-evaluation and cognition in older adulthood.

The frameworks of successful ageing (Rowe & Kahn, 1997; Weir et al., 2010), SOC (Baltes & Baltes, 1990), and cognitive reserve (Scarmeas & Stern, 2003), as well as studies showing the benefit of engagement in the course of attenuating or postponing cognitive decline (Hultsch, et al., 1999; Scarmeas et al., 2001; Schaie, 2005; Willis, et al., 2009) all require that an individual actively and deliberately engages in any activity (Weir et al., 2010). Self-evaluation and judging one's own cognitive performance is a crucial point in the course of expediently managing resources and regulate cognitive activities. If an individual is aware of her own strengths and weaknesses, interventions, training, and the use of strategies can be

applied expediently in order to maintain and stabilize the desired functional level facing real cognitive decline. So far, the validity of cognitive self-evaluation in relation to objective cognitive performance has been questioned (cf., Cavanaugh & Poon, 1989; Jorm et al., 2001). The results of the present thesis add evidence to the point that this might partly be an issue of the match between the specific domains being addressed subjectively and objectively. Also, the findings of the present thesis suggest that another reason for the repeatedly found small relation between subjective and objective cognitive performance might lie in the way the constructs are assessed: rather than assessing both constructs at a static, given time point, our results suggest that the longitudinal assessment of commonalities in change might be better suited to describe the relation.

Study 3 revealed that, overall, the relation between cognitive complaints and cognitive performance was small, even in a group of individuals who came to a memory assessment to explicitly seek help in coping with perceived cognitive problems. In samples in which cognitive complaints are assessed in the course of a scientific study, the question of cognitive complaints might appear artificial to the individual, hence might not be answered with one's own functioning as reference, but rather with the use of easily accessible heuristics. Research has shown that older adults rely more on heuristics, using easily accessible or salient information in a judgment task of low personal relevance. However, manipulating the relevance revealed that the age effect disappeared when the task is of importance to older adults (Hess, 2006; Hess, Germain, Rosenberg, Leclerc & Hodges, 2005). Additionally, judgement accuracy was enhanced in older adults by increasing the personal meaningfulness of a task (Hess, 1990; Hess et al., 2001). In a group of outpatients, the question of cognitive complaints should thus be of high importance and directly refers to the individuals' afflictions in everyday life. Although self evaluations and the evaluation of others are different tasks, one might speculate that the high relevance of cognitive performance in a

group of outpatients would lead to a higher accuracy in terms of evaluating one's own performance.

However, the strongest predictor for cognitive complaints was depression. This finding is in line with recent research (Mowla et al., 2007; Slavin et al., 2010), underscoring the strong affective component in evaluating one's performance. Global cognitive functioning (as assessed with the MMSE) was not significantly related to cognitive complaints. Taking into account manifold studies that advocate different developmental trajectories for different cognitive domains (Schaie, 1996; Singer et al., 2003), this finding could reflect that early stages of decline might not be ascertainable with global measures. Developmental trajectories of cognitive abilities have been found to differ as early as 10 to 5 years prior to diagnosis of dementia for fluid and crystallized measures, respectively, in healthy and later diseased individuals (Thorvaldsson et al., 2011). This finding suggests that an overall cognitive measure might not be distinct enough to detect subtle changes. Severely cognitively impaired individuals reported fewer complaints in the presence of objective severe memory impairments. This indicates that a global cognitive measure might not adequately address difficulties that influence the report of cognitive complaints. When cognitive impairments are as severe that they manifest in the MMSE, cognitive complaints might not be related to that anymore. This idea is supported by the fact that the MMSE is conceptualized as a screening instrument for dementia (Folstein et al., 1975). Additional support comes from the finding that the specific domain of executive functioning as operationalised in verbal fluency was significantly related to cognitive complaints (see also Benito-León, 2010). Executive functions are an important cognitive component in managing everyday activities (Hart & Bean, 2011). Cognitive self evaluation could hence be more strongly related to specific cognitive functions. To summarize, *Study 3* gives evidence that even in a group of individuals in which the level of cognitive functioning should be of high

relevance and highly salient, accuracy in evaluating cognitive performance is not necessarily high. The sample of the present study consisted of a group of objectively cognitive impaired individuals who experienced difficulties in everyday activities. Hence, cognitive demands of typical and stable everyday activities that usually imposed no maximal demands on the individual turned into high demanding tasks presumably reaching the maximal cognitive limits of an individual. In the presence of the transition where non-demanding, everyday activities turn into highly demanding, maximal performance tasks, cognitive functioning and its management should be highly salient to individuals in order to seek help or to stabilize and, ultimately maintain, individual functioning and well-being. However, because even in this extreme group, the relation between subjective and objective cognitive performance remained low with only 18% explained variance by cognition and affect, the question arises whether cognitive complaints at all serve the purpose of precisely monitoring cognitive functioning or if they are rather related to different internal processes that are necessary to maintain psychological well-being and intellectual functioning.

The second question addressed in chapter 3 of the present thesis (*Study 4*) was whether the small relation between subjective and objective performance might be partly a result of the assessment approach. Differences in affect, personality, and reference points (Albert, 1977; Arnkelsson & Smith, 2000; Kliegel & Zimprich, 2005; Metternich et al., 2009) could confound the assessed relation between the constructs. This could especially be true for constructs that are not assessed on the latent level, that is, assessed without measurement error (Meredith & Horn, 2001). In longitudinally assessing the commonality in change one is able to address and to account for those methodological difficulties (Zimprich et al., 2003). In other words, while in cross-section relations can only be assessed on the absolute level, longitudinally, individuals serve as their own reference group, hence the relative level of functioning can be depicted. Hence, in assessing the commonality in change, possible

absolute level differences are controlled for. The explained variance in the change correlations was about three times larger than in the correlation between the levels in *Study 4*. Thus, the results of the present study give evidence that individuals do rather monitor change. Note however, as a limitation of *Study 4,* that the commonality in change was only relatively larger compared to the relation at a given time point (r = .23 for levels, r = .39 for slopes). Overall, the relation found was moderate, which does not exceed usually reported correlations between the constructs (e.g., Cavanaugh & Poon, 1989). However, as the difference proved to be significant, the claim that assessing commonalities in change would be more informative remains warranted. Integrating the results of *Study 3* might partially explain the small correlations. If individuals report cognitive complaints as a function of importance of the special domain in which losses occur, than the results of *Study 4* could reflect that the importance of special domains was not controlled for. Cognitive complaints were assumingly assessed too unspecific. Hence, individual differences with regard to the importance of each domain were not controlled for but might have significantly biased the magnitude of the reported complaints.

4.3. The subjective side of cognitive development – integrating the 4 Studies

All four studies of the present thesis aimed at contributing knowledge to the field of non-cognitive aspects that can account for interindividual differences in cognitive development across the lifespan. Theories on lifespan development (Baltes & Baltes, 1990; Baltes & Schaie, 1976) as well as theories on cognitive development stress the importance of non-cognitive variables and the deliberate influence of an individual on the development across the lifespan (Ackerman, 1996, 2000; Hess, Leclerc et al., 2009; Scarmeas & Stern, 2003; Willis et al., 2009). In the present thesis, Typical Intellectual Engagement and self-evaluations of cognitive performance were investigated as non-cognitive variables. How can

the main findings of the present thesis be integrated and which future research questions can be derived from the overall findings? This is what I shall discuss in what follows.

Typical Intellectual Engagement (Ackerman, 1994; Goff & Ackerman, 1992) is conceptualized at the interface of intelligence, personality, motivation and interest. If this holds to be true, than the development of Typical Intellectual Engagement should comprise characteristics of all of these aspects. Results of the present thesis provide empirical support for this theoretical assumption (see above, 4.1.). Within the framework of SOC, cognitive reserve, and selective engagement (Baltes & Baltes, 1990; Baltes & Schaie, 1976; Hess, Germain et al., 2009; Scarmeas & Stern, 2003), Typical Intellectual Engagement can be seen as person characteristic that influences the amount and orientation of deliberately directed intellectual activity. Mechanisms that influence the orientation and the magnitude of Typical Intellectual Engagement might be abilities, lifelong habits, external environments (Hess, 2005; Schooler, 1984) but also the subjectively perceived necessity and capability of intellectual activity. Unimpaired as opposed to impaired cognitive functioning has empirically been found to be essential for subjective well-being in old age (Lawton et al., 1999). It has also been implemented into the definition of successful ageing (e.g., Rowe & Kahn, 1997). However, to be able to influence cognitive functioning within the boundaries of possibility, a veritable image of one's own cognitive performance is the mandatory prerequisite. Nevertheless, research on the validity of cognitive complaints in relation to objective performance has only exhibited small to moderate relations (e.g., Cavanaugh & Poon, 1989). Inferring from the findings of the present thesis, in what follows, I shall discuss suggestions that could contribute to the understanding of this small relation.

The report of complaints might be ability specific. It seems reasonable that processes that are strongly grounded on everyday activities are highly salient to individuals. Hence any deviations that are detected in these processes are experienced as a threat and may lead to

significant cognitive complaints. In future research, it could be informative to take into account not only affective states (and dispositions) and objective losses but also the subjective importance of a special (cognitive) domain in which losses occur. Hence, investigating interindividual differences in perceived importance of different domains that could contribute to the report of overall complaints might lead to a better understanding of the purpose of subjective complaints. The report of cognitive complaints might, overall, be a function of subjective importance. If this hypothesis was true, controlling for differences in importance should also result in higher correlations between subjective and objective cognitive performance in future analyses.

Interindividual differences in cognitive complaints might be stronger related to differences in motivation and interest (such as Typical Intellectual Engagement) that influence the personal importance of one domain over another than to differences in actual performance in this ability. While one individual might prioritize reading over problem solving, this might be the other way round for another individual. Hence, both might evaluate decline in cognitive mechanisms that underlie those activities differently with regard to the potential threat to personal well-being. The severity of reported cognitive complaints should vary as a result. In an extreme example, the same pattern of cognitive decline could lead to complete different subjective evaluations, and hence different reports of cognitive complaints. The interindividually different pattern of reported complaints and assessed performance might be interpreted as a lack of coherence between the two constructs. However, this interpretation would only be true if the purpose of cognitive complaints was defined as “reflect the objective environment as precisely as possible”.

One direction of future research, hence, could lay in the re-evaluation of the purpose of cognitive complaints. While it is important to monitor one’s own functioning, the question arises: is it necessary to monitor one’s own performances as a perfect replication of the

objective environment or is it more adaptive to monitor one's cognitive functioning in terms of matching one's priorities, necessities, and interests (see Hess, 2006). In the course of allocating overall reduced resources to maintain subjective well-being, domain specific monitoring of one's own performance might be most adaptive (Baltes et al., 1999; Hess, Germain et al., 2009). Depending on individual differences in motivation, interest and personality (e.g., Typical Intellectual Engagement) as well as distal environmental factors (see Hess, 2005) different specific domains should be evaluated as especially important. Interindividual differences in ability levels could manifest and influence cognitive complaints in a way that high ability individuals should report complaints in more domains. High ability individuals presumably have more resources for compensating deficits in more than one area at their disposal. Hence, concentration on more than one area of cognitive functioning could be possible for those individuals and hence several domains would remain important (see Lang, Rieckmann & Baltes, 2002, on the influence of resources). Another hypothesis concerning the influence of ability levels on cognitive complaints could result in the assumption that high level individuals report fewer cognitive complaints in general because they should be able to compensate declines longer and might also be more able to more effectively allocate declining resources. Different patterns of reported complaints could also emerge as a function of personality traits or levels of depression (Kliegel & Zimprich, 2005). Or, more generally spoken, instead of reliably reflecting cognitive functioning, cognitive complaints could rather reflect or be a part of the process of maintaining, regaining, or enhancing well-being.

Related to the point that depicting the "real world" might not be the most important purpose of evaluating one's own cognitive performance (see above), it could be more adaptive for an individual to monitor changes rather than static levels at a given time point. Thus, in order to adequately assess the functional relation between subjective and objective

cognitive performance, research could adopt and concentrate on the commonality in change between the respective constructs rather than assessing levels of both constructs at a given time point. Although the concept of correlated change is not a new one (e.g., McArdle & Nesselroade, 1994) and correlated change in subjective and objective memory performance has been addressed elsewhere as well (see Lane & Zelinski, 2003; Taylor et al., 1992; Zimprich et al., 2003), results were inconsistent and the topic has not been addressed as explicitly as in *Study 4*. Although the change correlation found in *Study 4* was significantly higher than the level correlation, the overall effect was only in the medium range.

On the one hand this might be due to the long time interval covered (12 years). On the other hand, the medium relation could be taken as an indicator for the assumptions made above, because assessing commonalities in change, that is assessing the dynamics of the two constructs, does also not account for the fact that subjective and objective evaluations might not be measuring the same. Subjective ratings could still be a function of specifically monitoring the most important aspects of cognition to an individual in order to adapt the engagement and the investment of resources in the most effective way concerning the maintenance of well-being (see above). This kind of "focussed attention" could facilitate the preservation of cognitive activities in domains that are prioritized over others by an individual. Indirect support for this idea comes from studies by Touron, Swaim and Hertzog (2007). They showed that the effectiveness of strategy use in older age was a function of the "attractiveness" of an incentive that was given as a reward after using the strategy or obtaining the goal which depended on the use of the strategy. This illustrates the fact that motivation plays a crucial part regarding cognitive performance as an outcome and also regarding monitoring cognitive operations and investing resources into attaining specific cognitive outcomes. Although the above argument addresses subjective self-evaluations within a different context, one still could use it as a hint that the purpose of subjective

memory performance ratings might be rather related to self-regulation and motivation than to the pure assessment of objective performance.

Of course, the formulated hypotheses and research questions are speculative and would need future research. The implications for future research that were developed in 4.3 emphasise the potential benefit of changing the theoretical perspective for understanding the relation between the constructs. Turning to a more social cognition perspective might be fruitful (e.g., Cavanaugh et al., 1998; Hess, 1990). The assumptions made are thought of as one possible way for research to gain additional knowledge of the purpose of subjective ratings over and above further attempts of explaining the mere relation between subjective and objective ratings. They are supposed as one possible future perspective to shed some more light on the underlying processes driving the relation between the constructs. The general concern underlying these ideas is that maybe in order to fully understand the relation between subjective and objective cognitive performance, one might need to adjust and start looking from a different perspective (cf., Hess et al., 2001; Hess et al., 2005; Touron et al., 2007).

4.4. Conclusion

The empirical evidence resulting from this thesis provides the following main messages: First, Typical Intellectual Engagement is a unique definable construct that differs from related constructs in its developmental trajectory across the adult lifespan. Second, the personality component as well as the motivational component of Typical Intellectual Engagement is reflected in its developmental trajectory; however, much more research in detail is needed to disentangle the personality and motivation components of Typical Intellectual Engagement. Third, cognitive self-evaluations might be related rather to specific abilities than global cognitive performance. Fourth, the commonality in change is a more

informative approach to investigate the relation between subjective and objective cognitive performance.

Finally, the central questions arising from the present thesis are: What are the basic constituents of Typical Intellectual Engagement and how do they develop and interact? What is the purpose of subjective cognitive performance ratings regarding successful development and the maintenance of high subjective well-being of an individual?

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ZUSAMMENFASSUNG

Die vier Studien, die in der vorliegenden Doktorarbeit vorgestellt werden, beschäftigen sich mit der übergreifenden Fragestellung wie und mithilfe welcher Prozesse Individuen ihre eigene kognitive Entwicklung managen, regulieren und aktiv beeinflussen. Zwei Aspekte wurden in der vorliegenden Arbeit genauer untersucht: Erstens wurde die Entwicklung von interindividuellen Unterschieden im Ausmaß in dem sich Individuen gezielt und bewusst intellektuell betätigen und somit ihre eigene kognitive Leistung beeinflussen näher untersucht. Zweitens wurde die Entwicklung von interindividuellen Unterschieden in der metakognitiven Fähigkeit die eigene kognitive Leistung einzuschätzen und der potentielle Einfluss dieses Prozesses auf die kognitive Entwicklung untersucht. Nach der fundierten Darstellung des theoretischen Hintergrundes in Kapitel 1, werden in Kapitel 2 die folgenden Fragen detaillierter adressiert: Gibt es Unterschiede in Typischem Intellektuellem Engagement zwischen jungen und älteren Erwachsenen? Ähneln diese Unterschiede bekannten Alterseffekten in theoretisch verwandten Konstrukten? (Studie 1). Wie entwickelt sich Typisches Intellektuelles Engagement über fünf Jahre im höheren Erwachsenenalter? (Studie 2). In Kapitel 3 wird die Genauigkeit von subjektiven Gedächtnisbeschwerden in einer Population von Individuen, für die das Management ihrer sich verringernden kognitiven Ressourcen entscheidend für ihre Funktionstüchtigkeit im Alltag sein mag, näher beleuchtet (Studie 3). In der untersuchten Population von ambulanten Gedächtnisklinikpatienten könnte die Genauigkeit von subjektiven Gedächtniseinschätzungen den Prozess darstellen, bei dem besondere Anstrengungen initiiert werden, die schlussendliche ein unauffälliges Funktionieren im Alltag zu gewährleisten. An sich hoch automatisierte Prozesse benötigen im Lichte abnehmender Ressourcen eventuell nun explizite Anstrengung und den gezielten Einsatz von Ressourcen. Aus diesem Grund sollten diese Prozesse in einer Gruppe

ambulanter Patienten salienter und besser erfassbar sein. In Studie 4 wurde die Frage adressiert ob der Zusammenhang zwischen subjektiver und objektiver Gedächtnisleistung präziser erfasst werden kann, wenn das Ausmaß der gemeinsamen Veränderung über die Zeit analysiert wird. Die empirischen Ergebnisse aus Studie 1 und 2 zeigen substantielle interindividelle Unterschiede in Typischem Intellektuellem Engagement, die nicht mit etablierten Intelligenz- oder Persönlichkeitsmessinstrumenten abgebildet werden können. Studie 3 und 4 zeigen, dass subjektive kognitive Beschwerden stärker mit spezifischen kognitiven Domänen als mit globalen kognitiven Tests im Zusammenhang stehen. Zusätzlich ist der Zusammenhang zwischen subjektiven und objektiven Gedächtniseinschätzungen höher, wenn das Ausmaß der gemeinsamen Veränderung erhoben wird. Trotz allem bleibt der absolute Zusammenhang zwischen beiden Konstrukten nur moderat. In Kapitel 4 werden die Ergebnisse der vorliegenden Dissertation in eine übergreifende Diskussion integriert. Einschränkungen der durchgeführten Studien werden ebenso wie ihre theoretischen Implikationen diskutiert. Ideen für zukünftige Forschungsprojekte, die sich auf die funktionale Relevanz von kognitiven Funktionen, metakognitiven Fähigkeiten und Intellektuellem Engagement konzentrieren, werden diskutiert und vorgestellt.

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